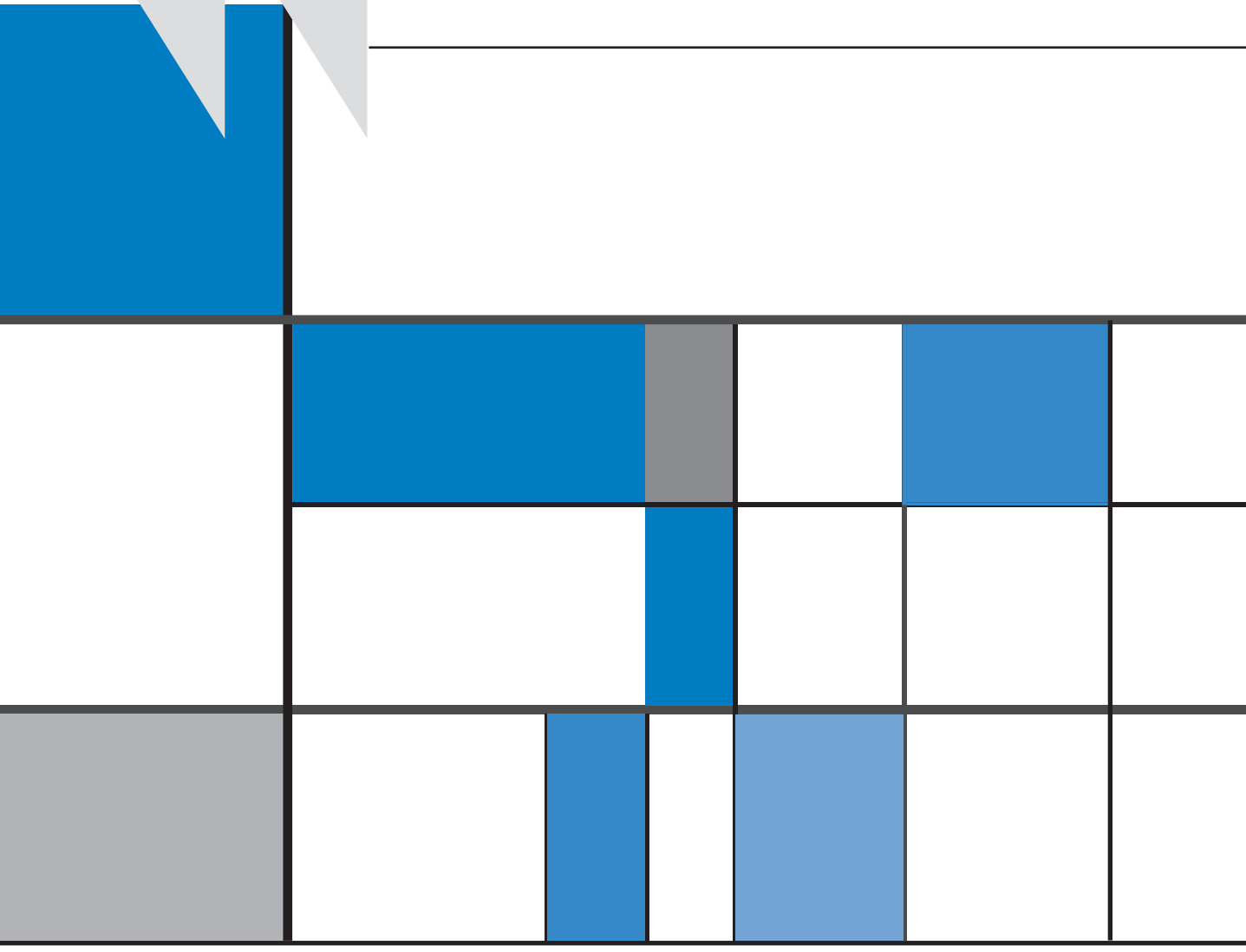
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Foreword

OECD Journal: Economic Studies *publishes articles in the area of economic policy analysis, applied economics and statistical analysis, generally with an international or cross-country dimension. While it draws significantly on economic papers produced by the Economics Department and other parts of the OECD Secretariat for the Organisation's intergovernmental committees, the submission of articles produced by non-OECD authors is encouraged. We also welcome comments on articles previously published in the journal.*

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What is the Private Return to Tertiary Education? New Evidence from 21 OECD Countries

by
Romina Boarini *and* Hubert Strauss*

This article provides estimates of the private Internal Rates of Return to tertiary education for women and men in 21 OECD countries, for the years between 1991 and 2005. IRR are computed by estimating labour market premia on cross-country comparable individual-level data. Labour market premia are then adjusted for fiscal factors and costs of education. We find that returns to an additional year of tertiary education are on average above 8% and vary in a range from 4 to 15% in the countries and in the period under study. IRR are relatively homogenous across genders. Overall, a slightly increasing trend is observed over time. The article discusses various policy levers for shaping individual incentives to invest in tertiary education and provides some illustrative quantification of the impact of policy changes on those incentives.

JEL Classification: I21, I22, I28, J24

Keywords: Investment in tertiary education, returns to education, labour market premia

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Internal rates of return (IRR) to education are a standard measure of the profitability of additional years of schooling. IRR estimates have increasingly relied on a sound analytical framework accounting for many different kinds of lifetime economic benefits and costs of schooling, including, among others, the well-known Mincerian wage premia. This article builds on such recent developments (de la Fuente and Jimeno, 2005) and on new estimates of wage premia (Strauss and de la Maisonneuve, 2009) to provide IRR estimates for men and women in 21 OECD countries covering the time period 1991 to 2005.

The main contribution of this paper is the use of cross-country comparable basic components of IRR, including labour market premia estimated on individual-level data sets, fiscal and social benefit parameters based on various OECD tax and benefit models, and higher education cost estimates from the OECD Education Data Set. The paper focuses on tertiary education decisions and thus provides IRR estimates specifically referring to an additional year of schooling beyond the upper-secondary degree.

We find that the cross-country average of the baseline IRR is above 8% in the period under scrutiny, and essentially varies in a range from 4 to 15%. IRR are relatively homogenous across genders. Overall, a slightly increasing trend is observed over time. At the end of the 1990s and in the early 2000s, IRR increased more markedly in Ireland and Canada, while they started declining in United Kingdom. Labour market premia turn out to be the main drivers of IRR, often irrespective of education costs. Beyond labour markets, return to schooling depends (positively) on average tax rates and the share of students' time worked; and (negatively) on marginal tax rates, study duration and tuition fees.

The article is organised as follows. Section 1 presents the analytical framework and discusses in detail the assumptions made in computing IRR. Section 2 elaborates on the construction of the basic components of IRR, namely labour market premia, fiscal and social benefit parameters and private costs. Section 3 shows estimates of IRR in the baseline scenario and in a number of alternative scenarios. It compares IRR estimates with those from previous studies and discusses their interpretation and their limitations. Section 4 illustrates the sensitivity of IRR by simulating changes in labour market outcomes and policy parameters. Section 5 concludes.

1. Methodological approaches to computing private returns to schooling

1.1. Education as an investment

According to human capital theory (Becker, 1967) individuals are supposed to undertake education up to the point where the present value of expected benefits from additional schooling is equal to that of its direct and indirect costs (*i.e.* tuition fees and foregone earnings). Education should increase the productivity of individuals, and more skilled workers are therefore expected to command higher salaries if labour markets are perfect and labour is paid at its marginal value.

Against this background, it has often been claimed that schooling decisions are endogenous and depend on the levels of innate ability, taste for schooling, access to funds

and the possible interaction of all these factors (Card, 1999). While in principle these factors may raise or lower the incentive to invest in education,[1] their net total effect is bound to be an empirical question; however, many studies find an only slight over-estimation of the "true" effects of schooling (around 10% of wage premia; Card, 1999).[2] Based on these findings, and due to data limitations, this paper does not take into account ability in estimating returns (unlike, *e.g.* Vella and Gregory, 1996). We assume the ability bias to be small and argue that the results are a reasonable approximation of the average return to schooling, even though they might slightly overestimate this average return if the schooling decision is endogenous to individual innate abilities. However, our IRR estimates neglect the earnings dispersion within a given educational level that is due to heterogeneity in ability, personal discount rates and other unobservable characteristics.

Another criticism of human capital theory is that individuals would not invest in education to increase their potential productivity, but rather to send a signal of their ability. In empirical studies signalling effects are, however, found to be rather small (less than 1%; Harmon *et al.*, 2003). Furthermore, from the perspective of guiding the individual decision to invest in human capital, the signalling effect is irrelevant, as individuals need a degree to signal their higher productivity; hence, whether the higher salary results from inherent ability or received education becomes immaterial. From the point of view of policy makers, it will, however, make a difference to know whether benefits from additional education stem from the value added of the education system itself or are partly due to students' innate abilities.

Another common assumption when computing returns to education is that benefits and costs are only pecuniary. While research has increasingly argued that education yields broader advantages to individuals (*e.g.* social prestige, better health, lower propensity to commit crimes, etc.; see Grossman, 2005), a sound empirical assessment of these non-pecuniary advantages is still lacking. In particular, the issue of measurement of these benefits is still largely debated, especially in the context of cross-country comparative work. For these reasons, this article takes into account only pecuniary benefits.

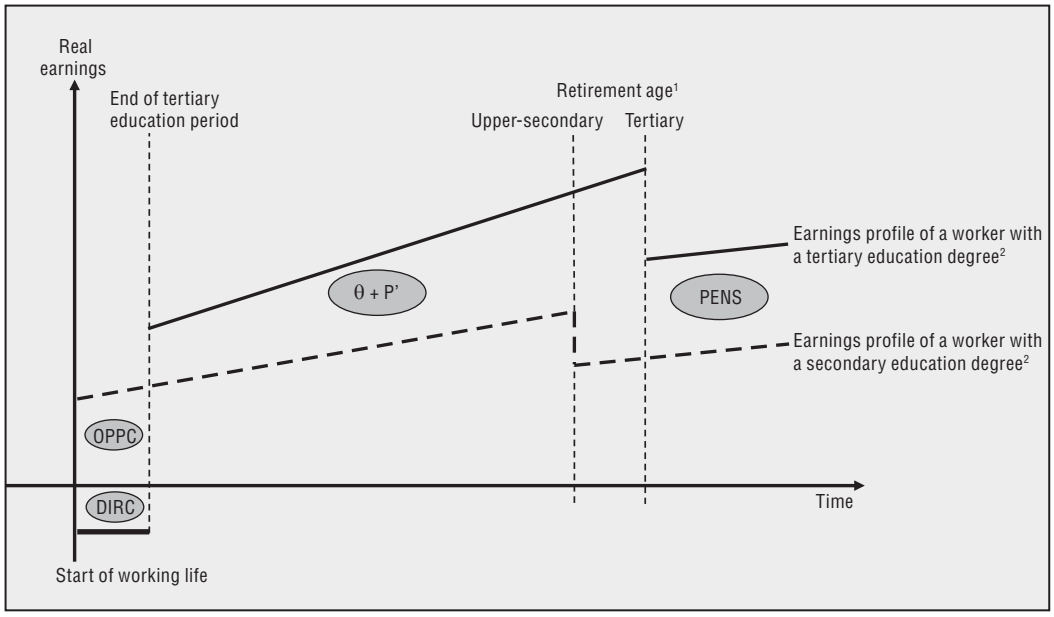
Many techniques of computing returns to education exist (see Psacharopoulos and Patrinos, 1994, Psacharopoulos, 1995, and Heckman *et al.*, 2005, for a review), but the most common are the discount method and the Mincerian approach. Heckman *et al.* (2005) have shown that these two approaches produce similar results under stringent assumptions.[3] In the discount method IRR summarise how profitable it is to undertake an additional year of schooling on the basis of the relevant stream of benefits and costs associated with it. The discount method has, however, some limitations since it often relies on average earnings across educational groups, without further controls for other individual characteristics. By contrast, the Mincerian approach relies on the econometric estimation of earning functions, based on individual-level data (see Mincer, 1974, and Harmon *et al.*, 2003, for a review). While this method has the merit of singling out the part of the earnings variance that is due to education, it clearly neglects the cost of education, as well as the taxes and social benefits that workers pay/receive over the life cycle.[4]

1.2. The analytical framework

This article essentially follows the approach developed in de la Fuente and Jimeno (2005) in combining the discount method and the estimation of Mincerian wage premia and other labour market premia from micro-level data (see Boarini and Strauss, 2007, for a formal presentation of the model).

Agents are assumed to choose the optimal level of schooling by maximising the present value of lifetime expected after-tax income, net of the direct costs entailed by education: IRR is indeed the discount rate equating the *marginal benefit* to the *marginal cost* (see Figure 1 for a stylised illustration). The marginal benefit from education can be decomposed into three components: the *net wage premium*, defined as the increase in wages entailed by an additional year of schooling and holding constant the employment probability; the *net employability premium*, given by the increase of the employment probability associated with an additional year of schooling, and holding wage constant; and the *pension premium*, *i.e.* the discounted value of higher retirement benefits due to higher lifetime labour earnings resulting from an additional year of schooling. The marginal cost of education is given by two components: the *opportunity cost of schooling*, *i.e.* the foregone earnings and labour-market experience due to continued schooling, and the *direct cost* of schooling borne by the agent, essentially given by tuition fees.

Figure 1. **Individual returns to tertiary education illustrated**



Notes: DIRC: Direct costs of tertiary education.
OPPC: Opportunity costs of not starting to work after secondary education.
θ + P': Wage and employability premia associated with tertiary education (net of taxes and benefits).
PENS: Retirement premia for tertiary education workers (net of taxes).
1. Assuming the same length of working life.
2. Assuming partial indexation of pension benefits.

In contrast to de la Fuente and Jimeno (2005), the baseline IRR constructed here does not include the possibility of students' part-time work, though alternative estimates of IRR under common assumptions on duration and reward of students' work are provided below.[5] The other assumptions are in line with de la Fuente and Jimeno (2005): the wage premium is an increasing and time-invariant function of schooling; the experience premium is constant across schooling levels (it is supposed to be a function of potential experience rather than actual years of employment and should grow at a constant rate over time); the employment probability is an increasing and time-invariant function of schooling; and individuals receive out-of-work benefits if unemployed and pay taxes on

either labour income or unemployment benefits, depending on their labour market status. Both benefits and taxes are constant over the life cycle but vary with schooling. The length of the working life is the same across levels of schooling. Some of these assumptions are relatively strong and have notably been rejected by empirical evidence on national samples (*e.g.* time-invariance of schooling premium in the United States; see Heckman *et al.*, 2005). However, these assumptions had to be made in absence of cross-comparable, sufficiently long panel data sets.

Moreover, as in de la Fuente and Jimeno (2005), the various IRR ingredients are either estimated on individual-level data through multivariate regressions (labour market premia) or drawn from various OECD tax and benefit models. In the latter case, tax and benefit parameters are those of a representative agent in the economy at 100% of average earnings (AE).

2. Computation of IRR components

2.1. Estimation of labour market premia: The use of individual-level data

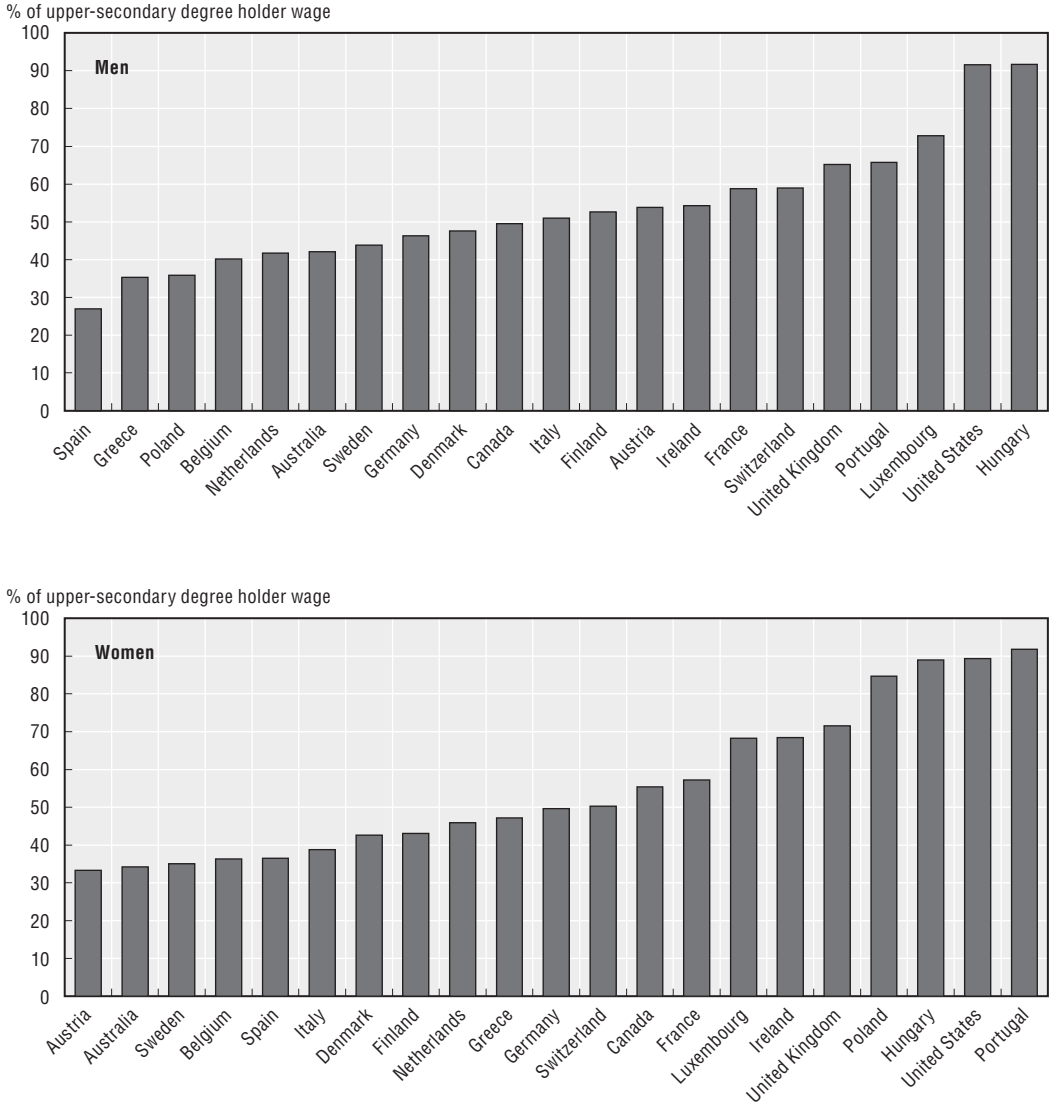
Labour market premia are computed using individual-level data from cross-country comparable household survey data sets (see Annex 1 in Boarini and Strauss, 2007). This kind of data allows estimating premia to education through multivariate regressions, controlling for individual heterogeneity with respect to a number of characteristics. Labour market premia are estimated country by country and period by period for three educational attainment levels (less than upper-secondary degree, upper-secondary degree, tertiary education). Labour market premia are also estimated separately for men and women.[6]

2.1.1. Wage and experience premia[7]

The wage premium on tertiary education and the labour market experience premium are obtained by regressing the log of gross hourly labour earnings on the level of educational attainment and on the number of years of labour market experience, as in the standard Mincerian approach. In the absence of relevant information on actual labour market experience, regressions make use of years of *potential* experience, proxied as the difference between current age and age at labour market entry. In addition, the estimation of wage and experience premia controls for a number of individual characteristics that potentially affect earnings but are not directly related to tertiary education. These include gender, marital status, job tenure, the type of work contract and working in the public *versus* the private sector. The estimates also control for the size of the production unit ("plant size") in which individuals are employed and over- or under-qualification for the job.[8]

Regression results of the wage equation are in line with priors for most variables. The Mincerian coefficient of tertiary education attainment, the gross wage premium, is found to be 55% on average and to vary widely across countries (between 27 and 92%; see Figure 2 and Strauss and de la Maisonneuve, 2009, for more details).[9] Women's tertiary wage premia are higher than men's in 9 of 21 countries, the difference being significant in Poland and Portugal, and moderate in Canada, Greece, Ireland, Spain and the United Kingdom. By contrast, male graduates appear to get significantly higher wage returns than their female counterparts in Australia, Austria, Finland and Italy. The tertiary education wage premium for men is the highest in Hungary (92%) and the lowest in Spain (27%). For women, wage premia are highest in Portugal (92%) and lowest in Austria (33%).

Figure 2. **Gross wage premia from tertiary education,[1] 2001[2]**

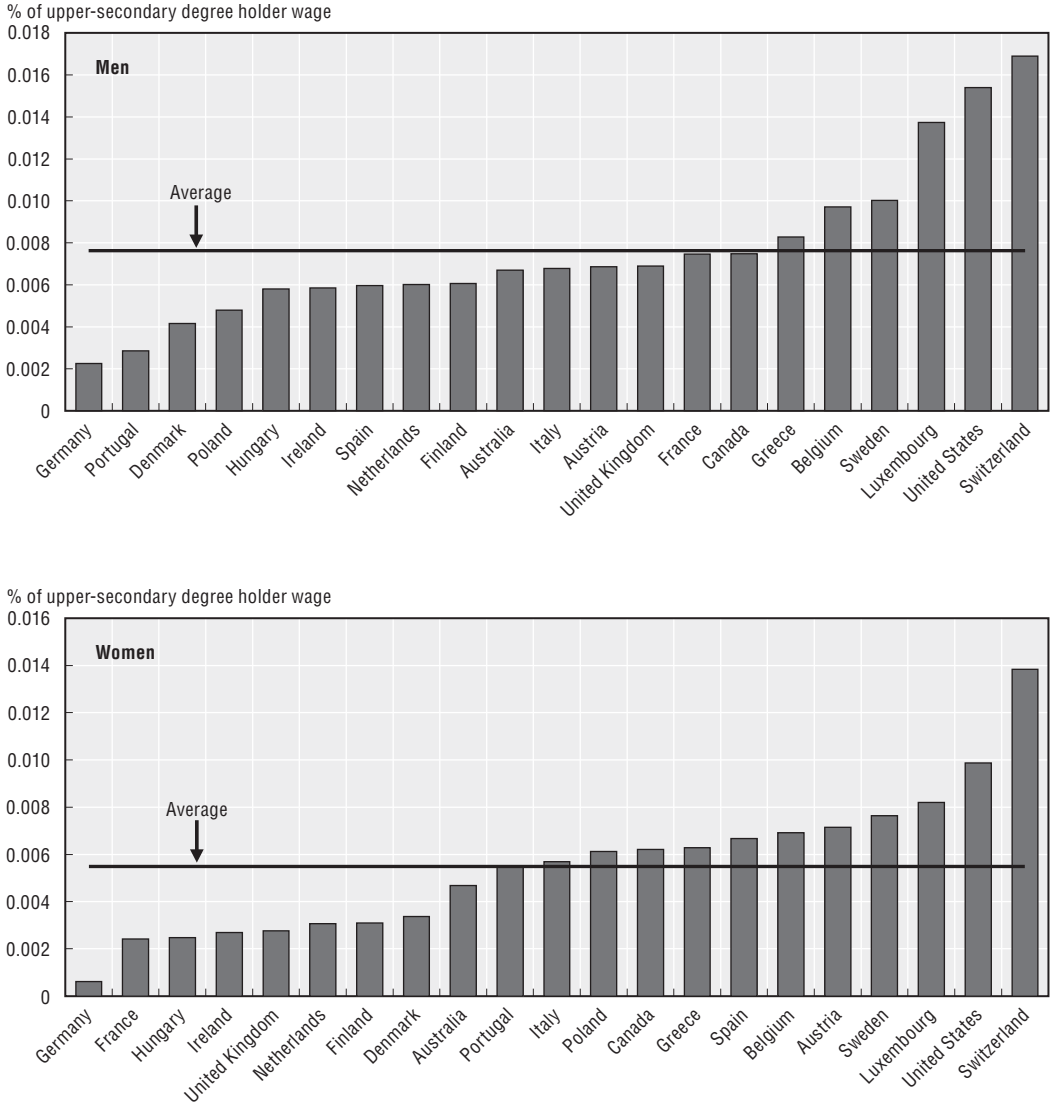


1. Estimates of the increase in gross hourly earnings relative to a worker with a secondary education degree, controlling for individual characteristics other than education attainment.
2. Except for Hungary 1997 and Poland and Switzerland 2000.

Source: The European Community Household Panel (ECHP), the Consortium of Household Panels for European Socio-Economic Research (CHER), the Cross-National Equivalent File (CNEF), the Household Income and Labour Dynamics in Australia Survey (HILDA) and OECD calculations.

The experience premium per year of accumulated labour market experience also shows large cross-country variation (Figure 3): it is the lowest in Germany (with the gender mean slightly above zero) and the highest in Switzerland (with the gender mean at 1.54%). Part of this variance could be explained by the role played by job tenure (*i.e.* experience specifically accumulated within a firm) in some labour markets, suggesting that firm-specific skills are more strongly rewarded than general labour market skills in these countries. Indeed, the coefficient of job tenure tends to be high where the experience premium is low, and *vice versa*. Finally, the experience premium is lower for women than for men. This might be partly due to the fact that most women in the sample have less seamless work histories than

Figure 3. **Experience premia from tertiary education, 2001**[1]



1. Except for Hungary 1997 and Poland and Switzerland 2000.

Source: The European Community Household Panel (ECHP), the Consortium of Household Panels for European Socio-Economic Research (CHER), the Cross-National Equivalent File (CNEF), the Household, Income and Labour Dynamics in Australia Survey (HILDA) and OECD calculations.

men. As a consequence, the variable "potential experience" measures women's actual experience with greater error – and in most cases overstates it more strongly – than is the case for men's actual experience, leading to lower coefficients.

Tertiary education premia are found to be fairly stable over time, particularly so in the second part of the period studied, *i.e.* between 1997 and 2001. However, over the period 1994-2001 upward trends are observed in Ireland, Denmark and Portugal (women) and to a lower extent in Greece, Germany (women), Italy (men) and the United States (men). Downward trends are recorded for Austria, Spain (excluding the end of the period), Portugal (men) and, to a slightly lesser extent, the United Kingdom (women). The premium on labour market experience is found to be very stable over time for both genders (see Table 6 in Strauss and de la Maisonneuve, 2007).

2.1.2. Employability premia

In addition to wage premia, the benefits of higher education usually include a lower unemployment probability. To take into account the possible selection bias[10] occurring from the fact that the unemployment probability can be estimated only for labour market participants, we use a two-step method (Heckman, 1979; Heckman *et al.*, 2005a). The first step determines the probability of participating in the labour market. The second step determines the probability of being employed given the probability of participating. The participation and employment propensities are supposed to be a function of individual characteristics, such as educational attainment, gender, age (quadratic specification),[11] marital status and presence of children in the household (see de la Fuente and Jimeno, 2005, and Ciccone *et al.*, 2006). The participation equation also includes controls for discouraged-worker effects (experience of long-term unemployment) and regional dummies for some countries.[12]

Results of estimations show that participation and employment probabilities are correlated (*i.e.* there is indeed selection) only in some countries and in some years.[13] The estimates are in line with expectations for most variables (see Boarini and Strauss, 2007, for a discussion). Education increases both the probability of participating in the labour market and that of finding a job. While for most countries one cannot reject the hypothesis that the impact of education on the employment probability is linear, there are a few exceptions (*e.g.* in Finland and the Netherlands, where further upgrading from upper-secondary to tertiary education increases the employment probability by more than upgrading from primary to secondary education).

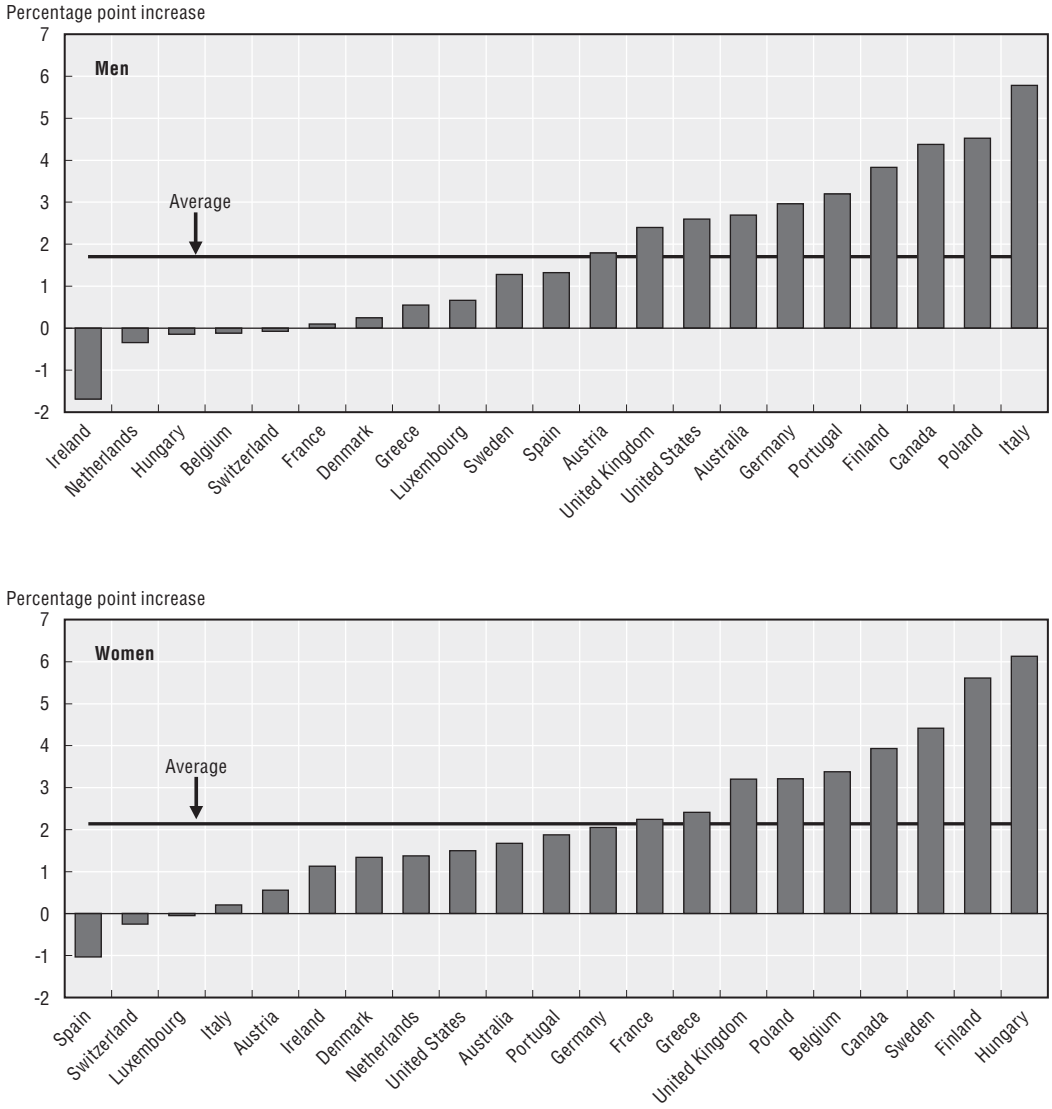
In 2001, the estimated conditional probability of employment for an upper-secondary degree holder was around 92% for women and 95% for men in most countries. With a tertiary education degree the employment probability increases on average by around 2 percentage points (Figure 4). The largest premia (*i.e.* the difference between the estimated employment probabilities for tertiary and upper-secondary graduates) are found for men in Italy, Poland and Canada, and for women in Hungary, Finland and Sweden. Small (or even negative) effects are found for men in Ireland, the Netherlands, Belgium, Switzerland and France, and for women in Spain, Switzerland, Luxembourg and Italy. Gender differences are particularly large in Italy and Belgium. Although the employability premia are estimated on micro-data and carefully isolate the education effect on employment from other characteristics, they are generally broadly in line with the gaps between aggregate unemployment rates of upper-secondary and tertiary degree holders.[14]

Perhaps not surprisingly, the employability premia display stronger cyclical sensitivity than wage premia.[15] They increase rapidly between 1995 and 1997, and fall monotonically afterward. The fluctuations are particularly marked for Spain and Italy, partly due to concomitant changes in labour market policies, often targeted at low-skilled workers. Moreover, the premium tends to decline in a majority of countries – reflecting that employment prospects improved more strongly for upper-secondary degree holders than for tertiary degree holders – and becomes more homogenous over time for men and women.

2.2. From the gross labour market premia to the net premium components of IRR

The estimated gross wage premia are adjusted for the effective duration of education, for the foregone experience premium as well as for average and marginal income tax rates. Finally, they are expressed as a percentage wage increase per year of tertiary education.[16]

Figure 4. **Marginal effect of tertiary education on the employment probability,[1] 2001[2]**



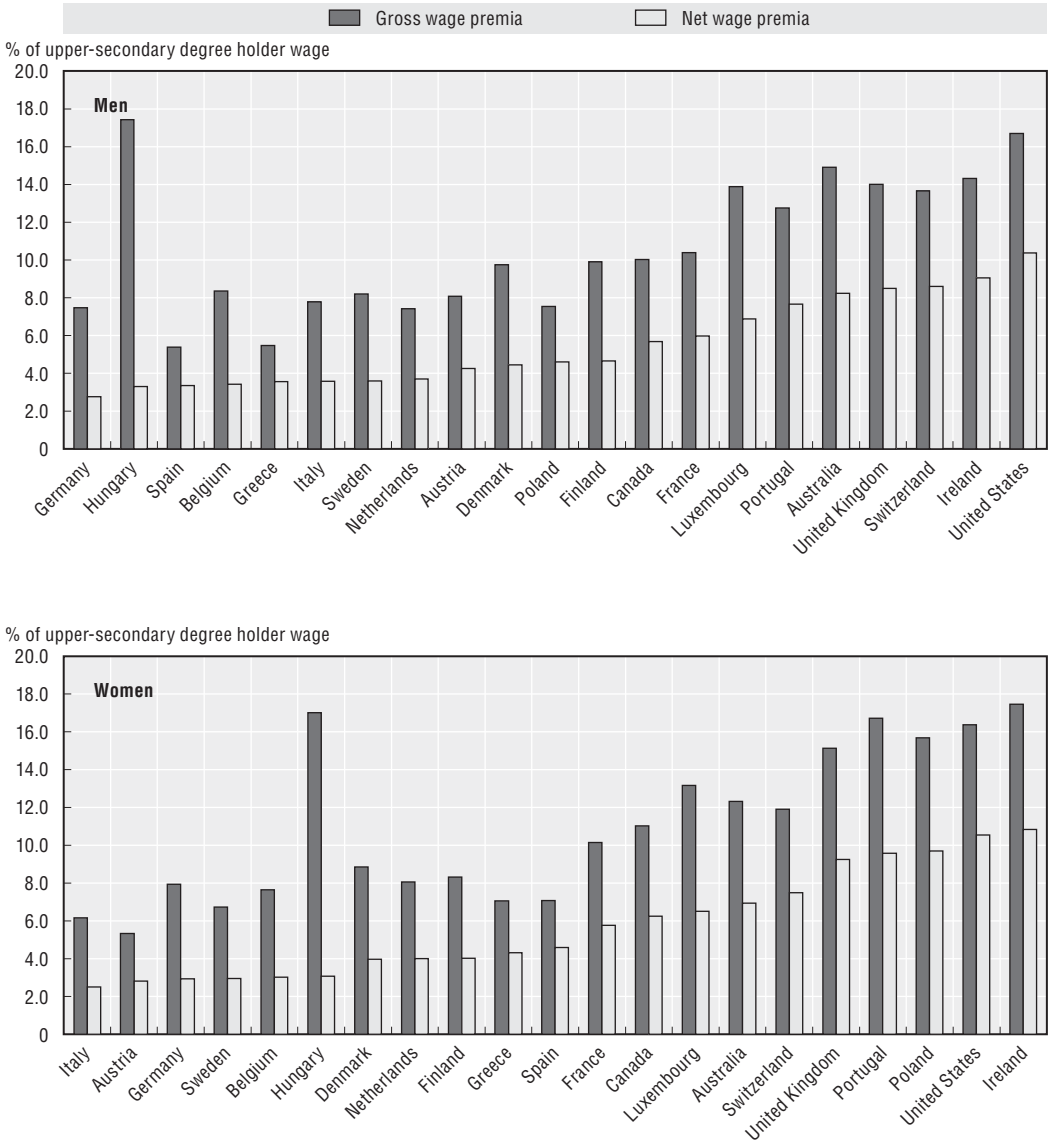
1. Increase in probability of employment: tertiary degree holders relative to holders of upper-secondary degrees.
2. Except for Hungary 1997 and Poland and Switzerland 2000.

Source: The European Community Household Panel (ECHP), the Consortium of Household Panels for European Socio-Economic Research (CHER), the Survey of Labour and Income Dynamics (SLID), the Household, Income and Labour Dynamics in Australia Survey (HILDA) and OECD calculations.

The net wage premium per year of tertiary education is quite different from the unadjusted wage premium both in absolute terms and from a comparative perspective (Figure 5). The latter is because duration, survival probability and taxation vary widely across the OECD area. The position of some countries, notably Hungary, Germany and Belgium, worsens considerably after these adjustments.

Before entering the IRR formula, the employability premia require an adjustment similar to that made for net wage premia. They are first expressed per year of tertiary education. Then *net* employability premia are derived from gross premia. The difference between gross and net employability premia depends on the out-of-work replacement

Figure 5. **Comparison of gross and net wage premium per year of tertiary education,[1] 2001[2]**



1. Adjusted for survival rates, experience premia, marginal tax rate for employed and unemployed, marginal gross out-of-work replacement rates, probability of unemployment and duration of studies. See Box 1, equation 3 in Boarini and Strauss (2007).
2. Except for Hungary 1997 and Poland and Switzerland 2000.

Source: Gross wage premia and unemployment probability are based on the European Community Household Panel (ECHP), the Consortium of Household Panels for European Socio-Economic Research (CHER), the Cross-National Equivalent File (CNEF) and the Household, Income and Labour Dynamics in Australia Survey (HILDA). Survival rates and duration of studies are from *OECD Education at a Glance*. Marginal tax rates are from the OECD Taxing Wages model. Replacement rates are from the OECD Benefits and Wages model.

income and the income tax treatment of replacement income.[17] In all countries net employability premia are much smaller than gross premia in absolute terms, the reason being the generally small difference between the net take-home pay and out-of-work replacement income. As a result, the magnitude of the net employability premium is small compared with that of the other drivers of IRR. In gross terms, employability premia are on average around ½ per cent whereas, in net terms, they decrease to only 0.1%.

2.3. Pension benefits

In computing IRR, pension benefits[18] are first adjusted by a tax factor and then discounted according to a representative market interest ratewhich is a function of labour productivity growth, the degree of indexation of pension benefits on wages, the length of the working life and the length of the retirement period. Portugal and Luxembourg display the highest net pension benefits, as a result of high replacement rates on pension benefits. On the other side of the spectrum, Finland and Italy are among the countries with the lowest net pension benefits owing to high taxation of pension benefits. By assumption, net pension benefits are received from the end of the active life until the expected death of the person so that differences in life expectancy and retirement age could change the country ranking with respect to net pension benefits. However, discounting those benefits (due to late occurrence in life) levels the country differences in the net pension premium on education.

2.4. Direct and indirect costs of education

In most countries, individuals do not bear the whole cost of education because funding to defray tuition fees and living expenses is publicly provided. This public support takes the form of either grants or loans (see OECD, 2006). The baseline estimates of direct costs presented below take into account grants for tuition fees but not for living costs.[19] This may imply a downward bias in IRR for Nordic countries, which are most generous in paying grants and loans for living costs to students.

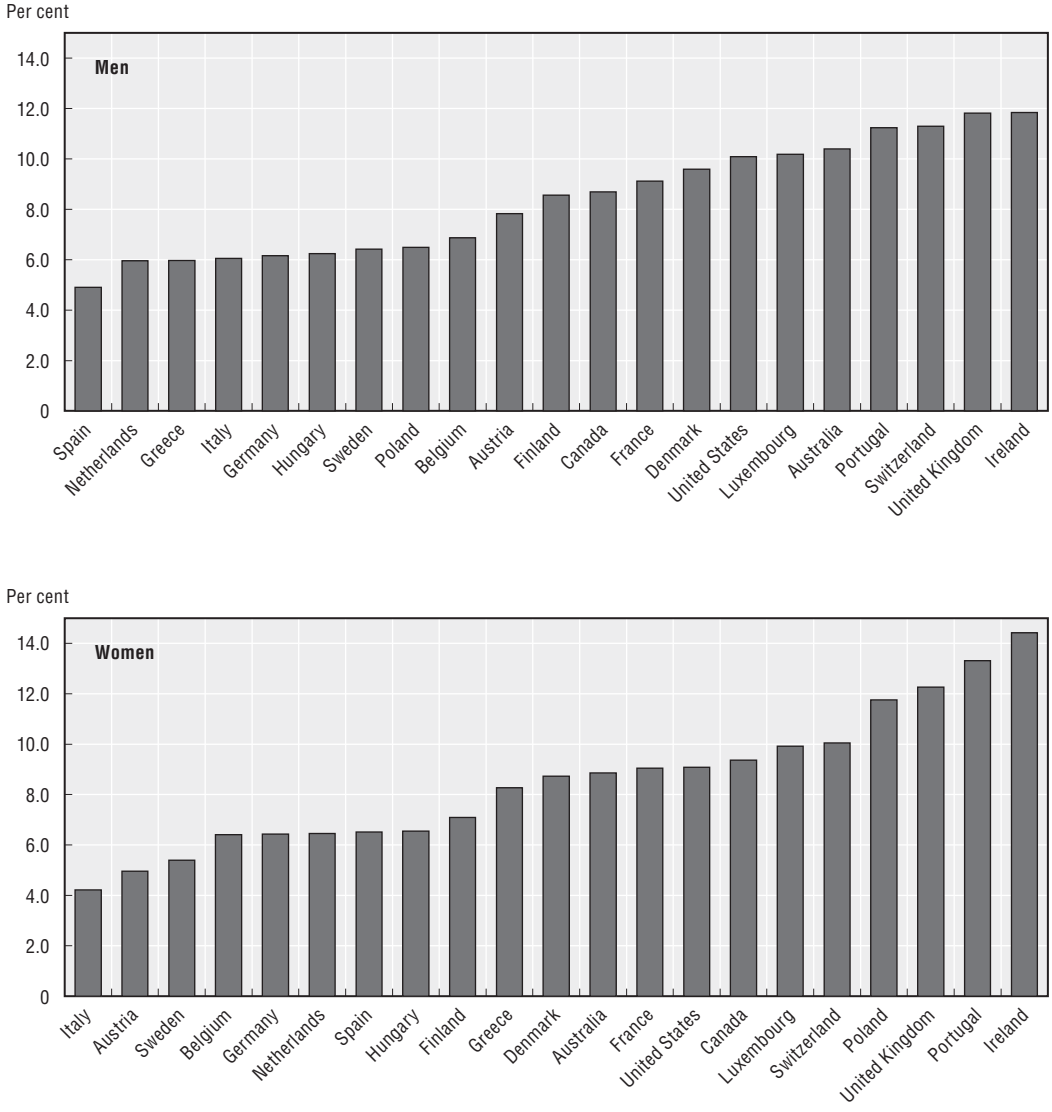
In practice, direct costs are obtained by combining three indicators: 1) annual total expenditure on tertiary education per student (including core educational services and R&D activities) (indicator B1.1 in OECD, 2005b); 2) the share of *final* expenditure borne by the private sector; and 3) the proportion of private final expenditure subsidised by the public sector, which covers only tuition fees (indicator B3.2b in OECD, 2005b). "Net" direct costs are thus given by the product of the annual total expenditure per student and the share of the *initial* expenditure borne by the private sector [given by 2) minus 3)].[20] In the baseline calculation, direct cost figures refer to 2002.

The opportunity cost associated with tertiary education consists of foregone labour earnings during tertiary studies, including both the wage of an upper-secondary degree holder and the premium on work experience accumulated while working (rather than studying). Opportunity costs are calculated as the average of net wages and unemployment benefits for an individual with upper-secondary attainment participating in the labour market, weighted by the probabilities of being respectively employed and unemployed.

3. Results for private IRR

Incorporating all the elements described above allows computing the baseline internal rates of return. Results for 2001 are shown in Figure 6. Internal rates of return vary across countries from 4 to above 14%. The average return (across countries and gender) is 8.5%, which is lower than previous OECD estimates but substantially higher than current market real interest rates. The range of returns for women is somewhat wider than for men (from 4 to 14.4% *versus* 5 to 12%). Low average returns are found (by ascending order) for Italy, Spain, Sweden, the Netherlands, Germany, Austria, Hungary, Belgium, Greece and Finland. IRR are moderate in Canada, France, Poland and Denmark. The highest returns are recorded in the United States, Australia, Luxembourg, Switzerland, the United Kingdom, Portugal and Ireland. In addition to the baseline, several alternative scenarios were estimated. They are

Figure 6. **Estimates of the internal rates of return to tertiary education, 2001**[1]



1. Except for Hungary 1997 and Poland and Switzerland 2000.

Source: OECD calculations.

discussed in detail in Boarini and Strauss (2007). Overall IRR estimates remain close to the baseline results, though in some cases country ranking varies considerably.

The baseline IRR is computed for the years 1991-2005 (Table 1). The cross-country cross-period average IRR is found to be slightly above 8% for both men and women, slightly less than the 8.5% observed in 2001. IRR vary more across countries than over time. Returns are relatively stable (see Boarini and Strauss, 2007, and Table 2 for a decomposition of the variance), with the OECD average increasing only slightly between 1994 and 2001 (Figure 7). The strongest upward trends are observed for Ireland, Portugal and Canada. Conversely, the United Kingdom displays a downward trend, especially at the end of the observed period.

Table 1. **Estimates of IRRs, various years**

In per cent

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Men															
Australia											10.4	10.2	10.1		
Austria					8.4	8.3	7.4	7.7	8.3	8.5	7.8				
Belgium				5.9	5.9	6.0	6.2	7.3	6.3	6.2	6.9				
Canada						7.3	5.9	7.1	7.0	8.7	8.7	8.4			
Denmark				5.4	7.0	6.5	6.7	8.1	8.5	8.4	9.6				
Finland						8.5	8.7	7.6	8.6	8.8	8.6				
France				9.5	9.3	9.4	9.8	10.2	9.3	10.1	9.1				
Germany				5.5	5.7	5.5	5.8	6.4	7.3	6.7	6.2				
Greece				5.4	5.2	5.6	5.7	4.9	5.8	6.0	6.0				
Hungary		7.3	6.4	6.4	5.0	6.8	6.2								
Ireland				7.2	8.1	8.5	9.8	9.0	8.8	8.6	11.8				
Italy				4.8	4.6	5.3	5.5	6.1	6.0	5.7	6.1				
Luxembourg					11.5	10.8	10.0	11.8	11.4	12.2	10.2				
Netherlands				6.9	6.9	6.7	5.6	6.3	4.4	5.0	6.0				
Poland							7.5	8.7	8.9	6.5					
Portugal				11.4	13.8	15.7	13.0	13.7	12.3	13.6	11.2				
Spain				5.0	5.4	5.5	4.4	3.9	3.1	2.2	4.9				
Sweden							6.4	7.3	7.2	7.0	6.4				
Switzerland									12.1	11.3					
United Kingdom	12.4	12.2	12.5	12.2	11.6	12.2	11.9	12.1	12.2	11.7	11.8	11.5	10.9	9.9	
United States				9.1	9.1	9.4	9.2	9.0	9.9	9.9	10.1	10.7	10.1	10.4	10.4
Women															
Australia											8.9	10.0	9.9		
Austria					9.3	9.5	7.5	6.9	7.1	5.7	5.0				
Belgium				4.4	5.1	4.4	5.4	5.5	7.4	6.0	6.4				
Canada						7.3	6.6	7.5	7.4	9.5	9.4	9.3			
Denmark				5.8	6.4	6.8	5.7	7.9	7.5	7.8	8.7				
Finland						6.5	6.1	5.8	6.7	6.4	7.1				
France				8.3	8.3	8.4	9.1	9.2	8.6	8.7	9.0				
Germany				5.2	6.0	5.3	5.9	5.9	6.5	5.7	6.4				
Greece				4.7	4.3	5.2	6.4	7.9	7.2	7.5	8.3				
Hungary		5.7	6.3	6.9	6.8	6.7	6.5								
Ireland				7.5	8.7	9.4	11.6	9.5	11.0	9.8	14.4				
Italy				4.3	4.4	4.2	4.3	4.4	4.5	4.8	4.2				
Luxembourg					12.2	10.4	10.1	11.2	10.5	10.9	9.9				
Netherlands				5.5	5.9	5.9	4.2	4.9	4.1	4.1	6.5				
Poland							9.2	10.3	11.3	11.8					
Portugal				10.6	11.3	12.6	11.5	13.3	12.2	15.6	13.3				
Spain				6.5	7.0	6.9	6.1	5.0	4.8	4.6	6.5				
Sweden							6.2	5.8	4.4	5.2	5.4				
Switzerland									10.4	10.1					
United Kingdom	12.6	13.9	13.3	12.7	12.7	12.3	12.6	12.8	12.2	11.5	12.3	12.1	10.9	9.9	
United States				8.6	8.6	8.9	8.7	8.5	9.0	8.9	9.1	9.4	8.7	9.2	9.1

3.1. Discussion of results

An abundant empirical literature exists on IRR. However, methodological differences in the computation of IRR, as well as relative paucity of cross-country comparative studies, make it problematic to compare IRR estimates presented here with those from previous studies. Psacharopoulos and Patrinos (2004) report IRR computed through the discount method (but not relying on microeconomic estimates of labour market premia) for a huge

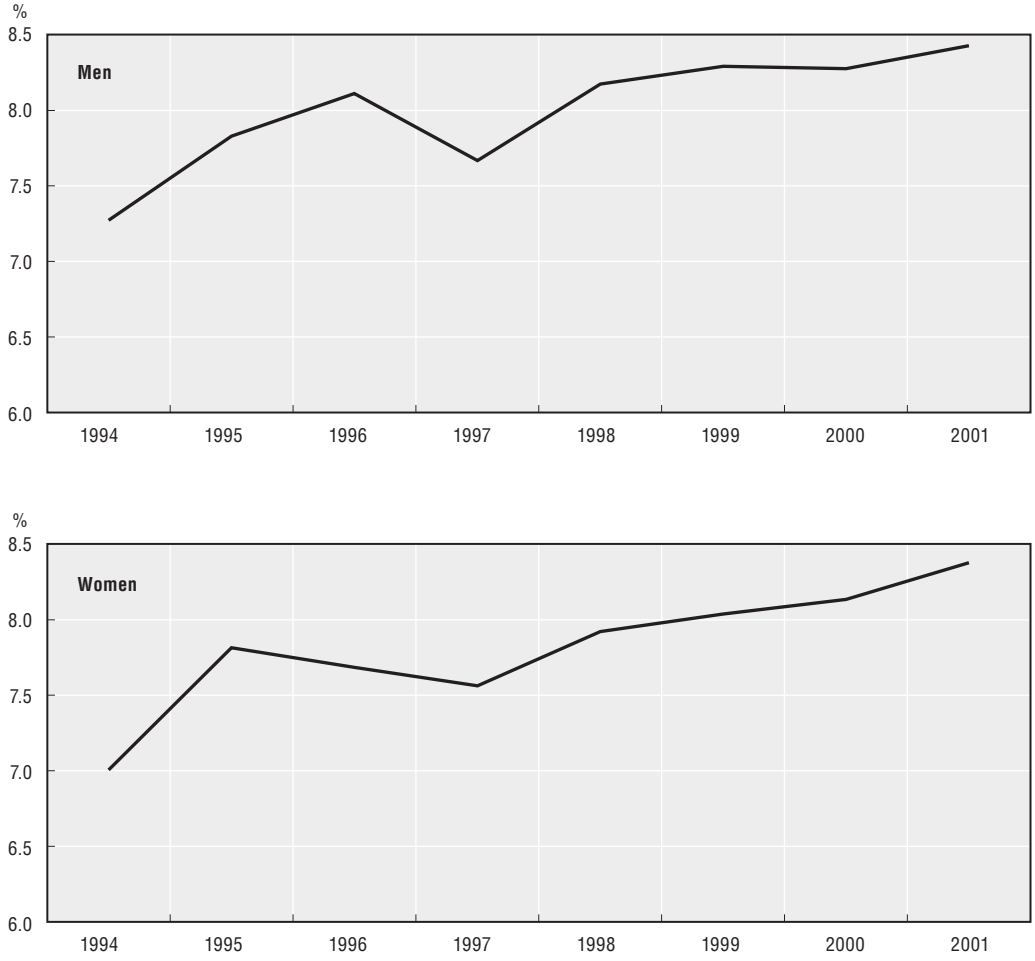
Table 2. **Variation across countries and over time of the main IRR components**

	IRR	Annual wage premia	Annual employability premia	Employment probability	Marginal tax rate	Average tax rate	Gross out-of-work benefits replacement rate	Net pension replacement rate
Cross-country coefficient of variation								
1994	0.31	0.44	0.74	0.07	0.32	0.26	0.34	0.41
1995	0.32	0.41	1.10	0.07	0.29	0.25	0.32	0.40
1996	0.30	0.40	0.91	0.07	0.28	0.24	0.30	0.42
1997	0.29	0.43	0.80	0.07	0.33	0.26	0.30	0.40
1998	0.29	0.39	0.94	0.06	0.26	0.27	0.30	0.42
1999	0.30	0.38	0.70	0.05	0.23	0.25	0.30	0.40
2000	0.33	0.40	1.05	0.05	0.24	0.26	0.30	0.40
2001	0.28	0.35	0.95	0.05	0.25	0.28	0.41	0.46
2002	0.11	0.20	0.32	0.03	0.09	0.03	0.44	0.60
2003	0.10	0.10	0.25	0.01	0.06	0.06	0.45	0.74
Over-time coefficient of variation								
Australia	0.04	0.07	0.26	0.01	0.00	0.02	0.19	0.85
Austria	0.15	0.18	2.27	0.01	0.00	0.02	0.17	0.15
Belgium	0.13	0.15	0.83	0.03	0.00	0.02	0.05	0.04
Canada	0.13	0.20	0.24	0.02	0.06	0.03	0.00	0.13
Denmark	0.15	0.18	1.27	0.02	0.01	0.02	0.07	0.09
Finland	0.15	0.14	0.46	0.03	0.03	0.05	0.05	0.35
France	0.05	0.08	0.96	0.05	0.04	0.01	0.01	0.53
Germany	0.08	0.10	0.51	0.02	0.02	0.03	0.01	0.01
Greece	0.18	0.20	0.75	0.08	0.11	0.02	0.28	0.08
Hungary	0.09	0.11	0.69	0.03	0.02	0.09	0.00	0.00
Ireland	0.17	0.20	1.12	0.03	0.19	0.18	0.15	0.01
Italy	0.13	0.11	0.67	0.06	0.01	0.03	0.06	0.16
Luxembourg	0.06	0.09	3.64	0.01	0.03	0.03	0.06	0.19
Netherlands	0.17	0.15	1.86	0.02	0.09	0.08	0.00	0.02
Poland	0.16	0.26	0.39	0.01	0.29	0.34	0.06	0.14
Portugal	0.09	0.12	0.58	0.02	0.01	0.03	0.16	0.16
Spain	0.26	0.21	1.16	0.12	0.03	0.04	0.05	0.03
Sweden	0.15	0.16	0.46	0.03	0.02	0.04	0.00	0.00
Switzerland	0.07	0.10	8.65	0.01	0.02	0.01	0.00	0.06
United Kingdom	0.06	0.09	0.58	0.02	0.01	0.04	0.13	0.06
United States	0.07	0.05	0.21	0.01	0.01	0.01	0.16	0.12

Note: The coefficient of variation across countries is only shown for years where it was possible to compute IRR for at least three countries.

sample of countries (including many non-OECD countries). They find average IRR to higher education of 11.6% for OECD countries. Blöndal *et al.* (2002) compute private internal rates of return to tertiary education at the end of the 1990s for ten countries and estimate higher returns than this study, varying in the range of 7.5% (Italy) to 18.5% (United Kingdom), with an average value of 11.6%. De la Fuente and Jimeno (2005), which this paper closely follows, compute returns for some European countries which range between 4.28% (Sweden) to above 12% (United Kingdom), with a 15-EU-country average of 8.8% (slightly above our estimates). Differences relative to results in this study are especially large for Italy, Greece, Spain and Germany, possibly reflecting different data sources for the estimation of labour market premia.

Figure 7. **Evolution of OECD average IRR between 1994 and 2001**



1. Country average is computed on a time unbalanced panel with a minimum of 13 observations.

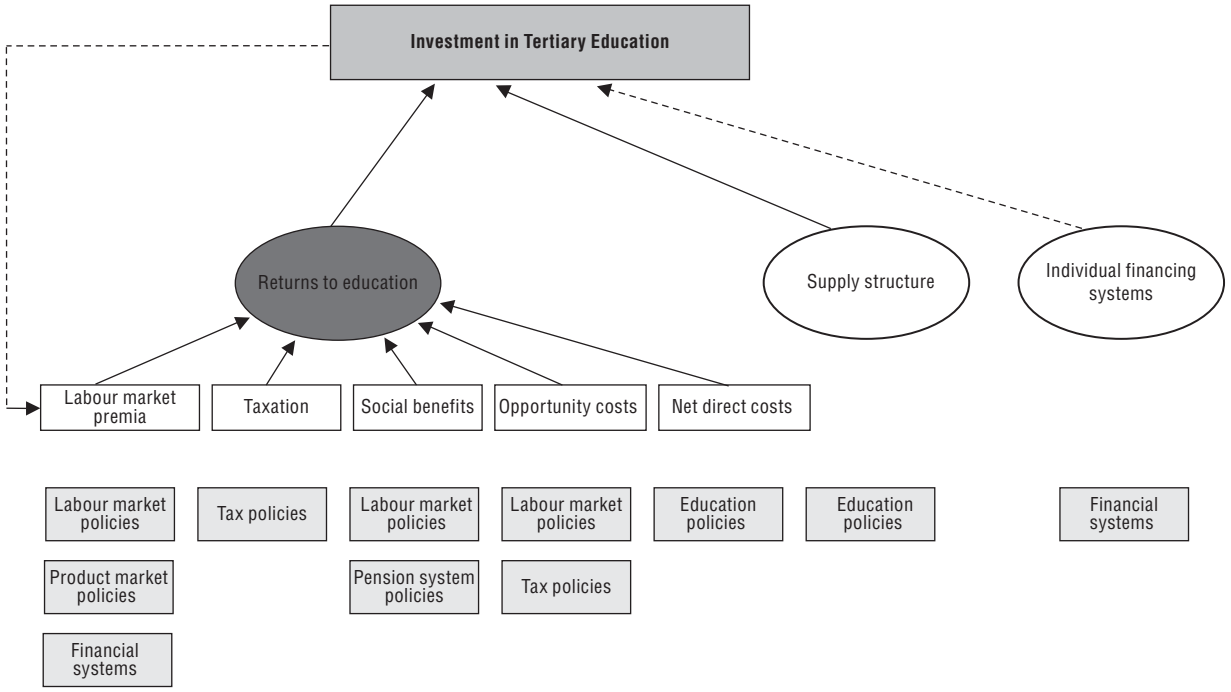
Despite efforts to compute IRR as accurately as possible, some limits of this method need to be pointed out. First of all, IRR shown above refer to an average individual, so that they do not reflect heterogeneity in a number of possible dimensions, notably ability, quality of education received, field of studies and possible liquidity constraints affecting students. Lacking a distribution of IRR for each of these dimensions, estimates should just be read as country-average returns for a representative individual.[21]

A second remark pertains to the general interpretation of IRR and to the possible explanation of cross-country differences in their levels. IRR depend on many factors and yet their main component is the wage premium. High wage premia may result from market forces, possibly reflecting scarcity rents, but also from specific labour market institutions, for example, country-specific aspects of the collective-bargaining system or of employment protection legislation. For this reason, IRR (or wage premia) provide only a very rough proxy of labour productivity of tertiary-educated workers and should rather be read as a proxy for the average individual's incentives to undertake tertiary education. The related question for policymakers is then how to act on these incentives, if the final goal is to increase tertiary human capital.

4. The impact of policies on IRR

Tertiary education and broader economic policies may affect the quantity of human capital accumulation either directly, for instance, by acting on the characteristics of tertiary education supply, or indirectly, by increasing or decreasing private incentives to invest in tertiary education (Figure 8). Many policy levers exist for increasing incentives to study. Labour markets are crucial to shape returns from education investment, as policies regulating wages and employment protection have a direct bearing on wage and employment premia. But other framework policies also matter for returns to education, for instance, product market regulation which has an impact on labour productivity and thus on IRR (see Oliveira *et al.*, 2007). Tax policies and welfare policies (unemployment and pension benefits) also matter for incentives to invest in education. Finally, education policies, in particular those governing financial support to universities and students, determine the costs sustained by students and thus the incentive to study. This section addresses the impact of some of these policies on private incentives by analysing how IRR respond to changes in labour market characteristics and education, social and fiscal policies.

Figure 8. **Policies affecting investment in tertiary education and IRR**



4.1. *Main influences on IRR: Policies and labour market outcomes*

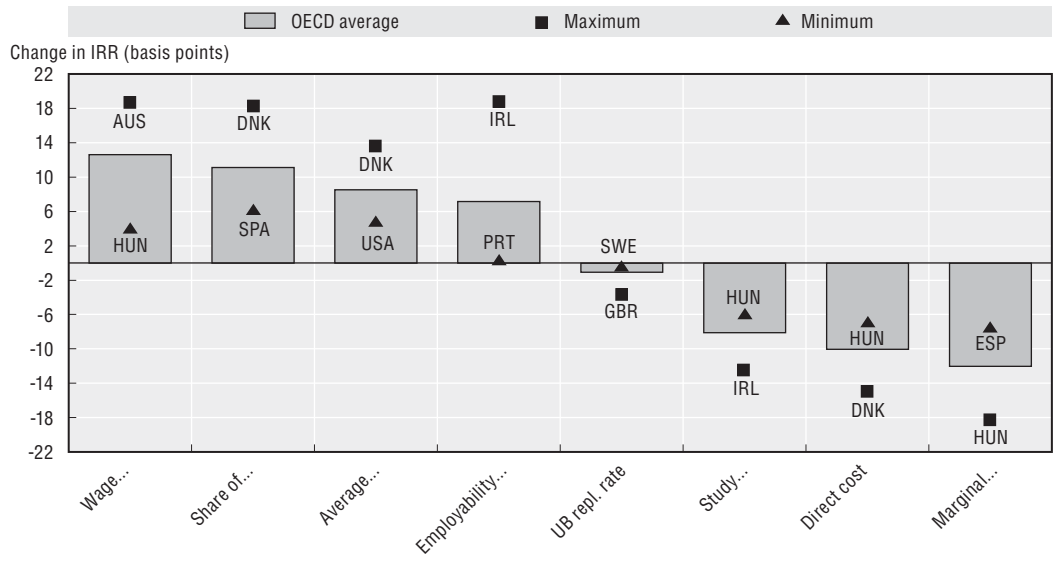
This part of the sensitivity analysis looks at the elasticity of IRR with respect to their main drivers, with the objective of assessing to what extent cross-country differences in IRR depend on cross-country differences in underlying components. Only one component is changed at a time, holding all the others constant except for obvious cases such as an increase in study duration, which is assumed to shorten the working life accordingly. All changes amount to 1 percentage point increases (except for study duration, which is changed by 1%) and refer to the 2001 baseline results.[22]

Figure 9 summarises the main results on IRR elasticities. It shows both OECD average elasticities and the range of elasticities across countries. These results can be summarised as follows:

- *Fiscal policy:* A strong progressivity of taxation may be detrimental to incentives to invest in human capital, as net labour market premia to higher education obviously become less attractive. Indeed a higher marginal tax rate reduces the net wage premium (elasticity slightly above 0.12). But the average tax rate matters, too: a higher *average* income tax rate tends to increase IRR, mainly via a reduction in opportunity costs, which represent the bulk of total private costs. Overall, the net effect of a joint increase in average and marginal tax rates depresses IRR in all countries, suggesting that progressivity of taxation matters more than the average tax rate for the incentive to study.
- *Social policy:* An increase in the *average unemployment benefit (UB) replacement rate* dampens labour market returns to education (as long as tertiary degree holders have higher employment probability than upper-secondary degree holders) and slightly increases the expected opportunity cost of studying. We find the net effect on IRR to be very small, reflecting the small net employability premia on tertiary education reported above.
- *Education policy: Higher tuition costs* (as a fraction of gross annual earnings of the average upper-secondary degree holder) have a direct negative effect on IRR (elasticity around 0.1). A marginal increase in the *study duration* also reduces the return per year of tertiary education. However, if students devote a higher share of their time to paid work (share assumed to be zero in the baseline), this significantly reduces opportunity costs.
- *Labour market characteristics:* An increase in the gross wage premium on tertiary education by 1 percentage point increases the private IRR by 0.13 percentage points on average. At 0.07 percentage points, the average increase resulting from a higher employability premium is smaller, as any increase in net lifetime earnings due to the higher conditional

Figure 9. **Sensitivity analysis on the internal rates of return,**[1] **2001**[2]

Male-female average



1. All drivers of IRR are changed by 1 percentage point except for study duration that is changed by 1%.
2. Except for Hungary 1997 and Poland and Switzerland 2000.

Source: OECD calculations.

employment probability of tertiary degree holders is partly undone by the concomitant loss of unemployment benefits, which are usually taxed at much lower rates than labour earnings. A non-negligible IRR effect of changes to the gross employability premium is observed only for countries where the difference between the take-home pay and the net unemployment benefit is large (*e.g.* Australia, Austria and Ireland).

Over and above those reported, a number of other parameter changes have been analysed. In most cases, their IRR effect is very small, such as for the pension benefit replacement rate, the degree of pension indexation, the length of the working life and the average experience premium. However, increases in the growth rate of average labour productivity raise IRR almost one to one and are therefore important for policy makers concerned with tertiary education incentives.

4.2. The differential impact of labour market characteristics and policies in individual countries

A second round of simulations consists of setting wage and employability premia, as well as private costs, to the upper end of their respective cross-country distributions so as to illustrate country-specific effects of policy changes. Conversely, tax rates are set at the lower end of their cross-country distribution.

4.2.1. Wage premium

Since IRR are most sensitive to gross wage premia, countries with moderate wage differentiation may gain in terms of tertiary education incentives from allowing for stronger differentiation. Policies and institutions contribute to compressing the distribution of gross wages (Katz and Autor, 1999). At the low end of the distribution, binding minimum wages and strong employment protection legislation (EPL) may grant workers a higher gross wage than would be warranted by their marginal productivity. At the high end, corporatist wage bargaining institutions (as measured by union density and the coverage of employment contracts by collective agreements) usually lead to some income sharing between high- and low-productivity workers. To illustrate possible gains from a higher wage premium, the latter is set to two standard deviations above the country mean.[23] With all other parameters remaining unchanged, IRR would increase by between slightly less than 1 percentage point in Portugal and almost 8 percentage points in Australia (Figure 10).

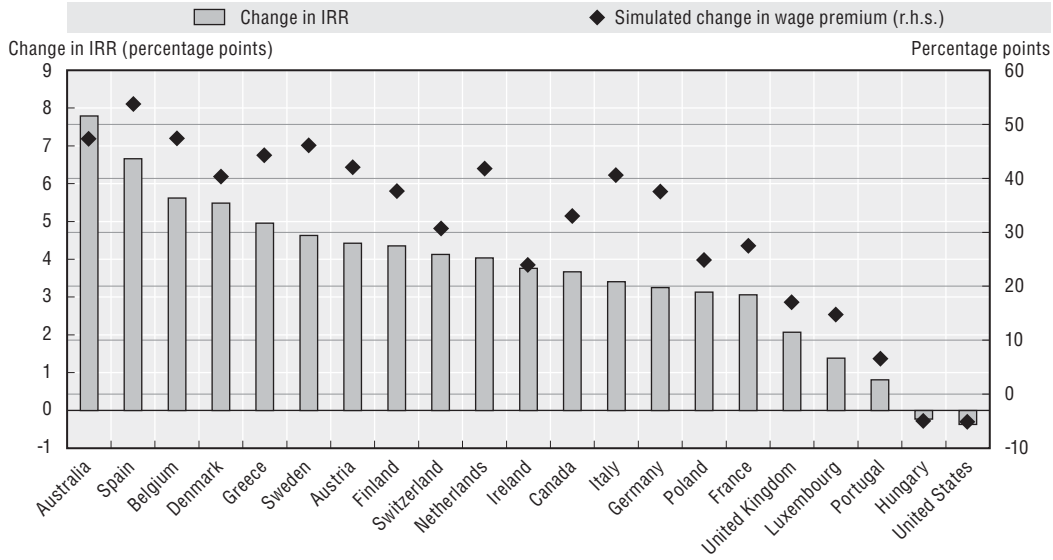
Overall, the lower is the initial *gross* wage premium, the higher the increase in IRR resulting from the simulation. Aside from this intuitive relationship, the increase in IRR also depends on the other parameters affecting the *net* wage premium, notably taxation and duration of studies, and on private costs. For example, in Ireland, where the marginal income tax is moderate and study duration is relatively short, the IRR increase would be stronger than in Germany and Italy, even though the simulated change in the gross wage premium is smaller. Likewise, the strong IRR increase in Australia mainly reflects short average study duration. Finally, as a rule, any increase in labour market benefits (numerator of the IRR calculation) is amplified if total private costs (denominator) are low.

4.2.2. Employability premium

If the employability premium were to be two standard deviations above the cross-country mean everywhere,[24] it would have to rise by 2 percentage points on average. This is modest compared with the wage-premium changes simulated above. Even with this

Figure 10. **Changes in IRR induced by higher gross wage premia,[1] 2001[2]**

Male-female average

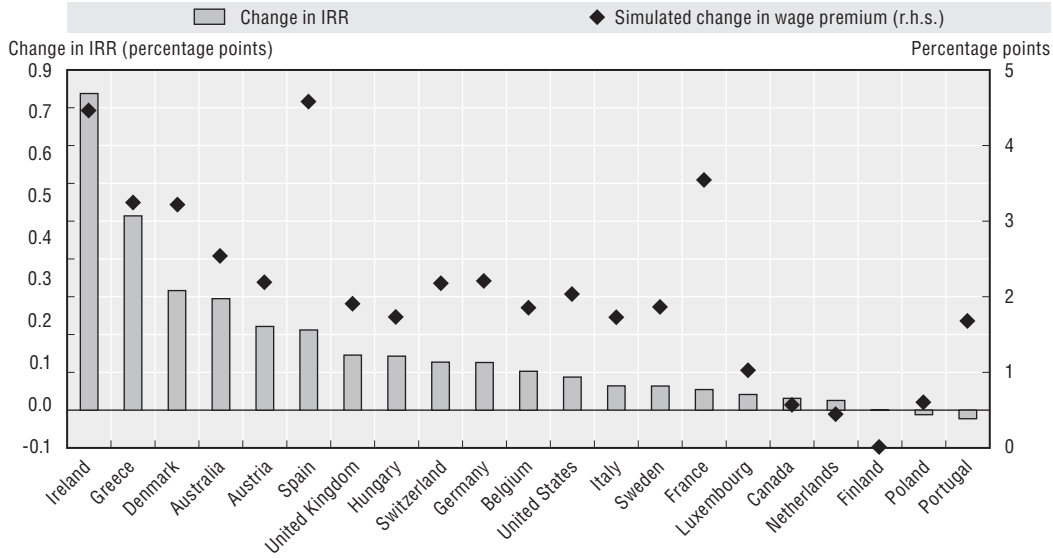


1. In this simulation the gross wage premium is set to two standard deviations above the country mean. In Hungary and the United States, where the wage premium is already higher than the simulated value, IRR would fall.
2. Except for Hungary 1997 and Poland and Switzerland 2000.

Source: OECD calculations.

Figure 11. **Changes in IRR induced by higher gross employability premia,[1] 2001[2]**

Male-female average



1. In this simulation the gross wage premium is set to two standard deviations above the country mean. In Poland and in Portugal, where the employability premium is already higher than the simulated value, IRR would fall.
2. Except for Hungary 1997 and Poland and Switzerland 2000.

Source: OECD calculations.

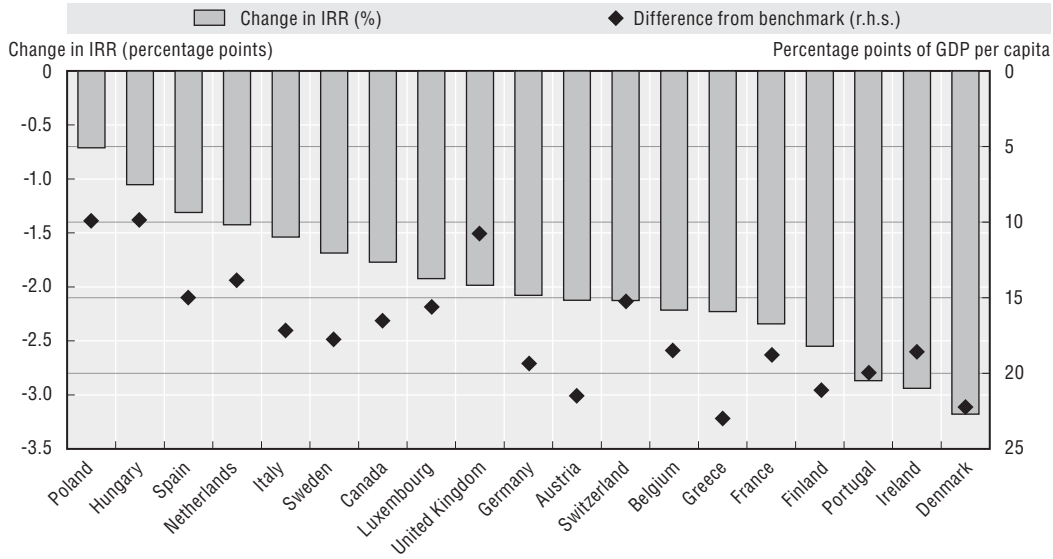
different impact in mind, the resulting average IRR effect (less than 0.2 percentage points) is extremely small (Figure 11). Changes in IRR would be the highest in Ireland and the lowest in Poland and Portugal.

4.2.3. *Private direct cost*

Higher net private costs would reduce IRR if other policy settings did not change at the same time. Again, the illustrative exercise consists of setting net private costs (as a fraction of GDP per capita) equal to the mean plus two standard deviations, which happens to be almost exactly equal to the Australian level but still well below the cost levels applied in the United States. The simulated increase in private costs is substantial in all countries, ranging from 10% of GDP per capita in Hungary and Poland to 22.9% in Greece. The fall in IRR lies between 0.7 percentage points in Poland and slightly more than 3 percentage points in Denmark (Figure 12).

Figure 12. **Changes in IRR induced by higher direct costs,[1] 2001[2]**

Male-female average



1. Net private costs are set to the country mean plus two standard deviations.
2. Except for Hungary 1997 and Poland and Switzerland 2000.

Source: OECD calculations.

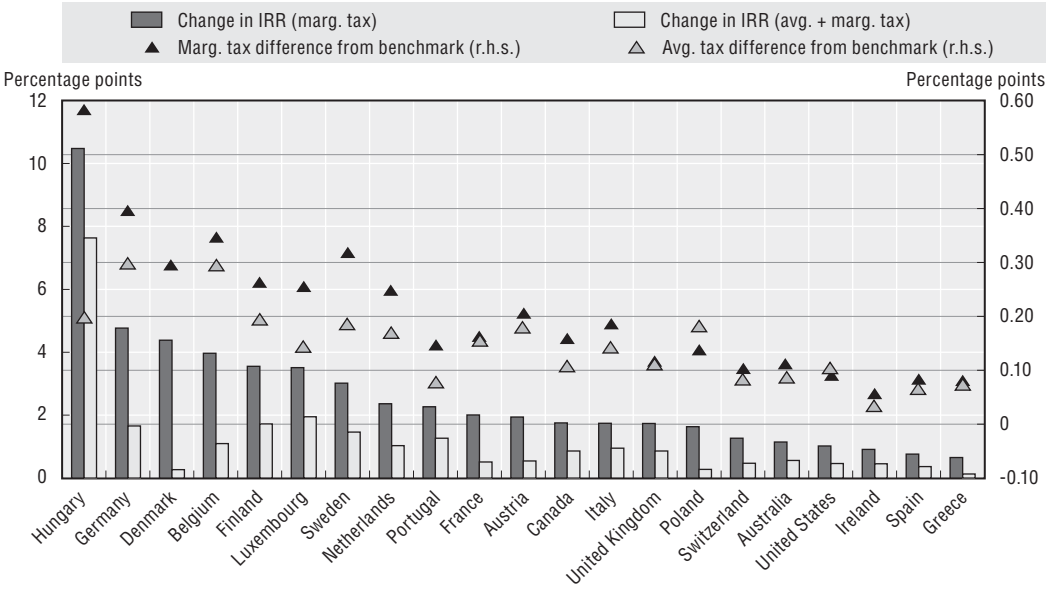
The effect on IRR of a *given* increase in the cost-to-income ratio is stronger the lower the initial level of costs (*e.g.* Austria, Belgium, Germany and Greece have levels much below the country mean) and the higher the labour market benefits to education (*e.g.* above-average levels for Ireland and the United Kingdom). A low (high) initial level of costs implies a large (small) simulated change in costs, leading to a strongly (weakly) negative effect on IRR. Yet the impact on IRR is cushioned somewhat by the fact that countries with low private costs also tend to have below-average labour market benefits.

4.2.4. *Marginal and average income tax rates*

As discussed above, the joint effect on IRR of setting marginal and average tax rates on labour earnings at the lower ends of their respective cross-country distributions is positive. Here the effects of tax reforms are assessed in two steps. In the first step the marginal tax rate is set at 20%, while the average tax rate is left unchanged. This leads to substantial IRR increases (Figure 13). In the second step, average tax rates are also set to the lower end of the distribution.[25] The total IRR effect is positive and ranges from 0.1 percentage point in

Figure 13. **Changes in IRR induced by lower income tax rates,[1] 2001[2]**

Male-female average



1. Marginal and average tax rates are, respectively, set at 20% and 13.3% (the lowest values in the sample).
2. Except for Hungary 1997 and Poland and Switzerland 2000.

Source: OECD calculations.

Greece, Denmark and Poland to 7½ percentage points in Hungary, with the effect exceeding 1 percentage point in four more countries (Finland, Germany, Luxembourg and Sweden). Indeed, IRR increases induced by sharp reductions in the marginal tax rate are undone by cuts in the average tax rate that increase opportunity costs.

5. Summary and conclusions

This paper provides estimates of private internal rates of return (IRR) to tertiary education for 21 OECD countries in the period 1991-2005. The high degree of cross-country comparability of the basic components entering these estimates – net wage premium, net-income equivalent of higher probability of being employed, net pension premium, direct costs and opportunity cost of studying – represents a major strength of the article. Labour market returns have been obtained by cross-sectional regressions based on individual data from international panel data sources, which allow controlling for a number of individual characteristics when estimating the effect of education on gross wages and on the conditional probability of being employed. Various OECD databases are used to adjust the estimated gross labour market premia for tax and benefit parameters and the duration of, and survival probability in, tertiary education. They also calculate the average private cost of tertiary education.

We have shown that returns are on average above 8%, thus substantially higher than returns to comparable financial investments. We have also illustrated the variety of policy levers that shape individual incentives to invest in tertiary education. Sensitivity analysis has shown that IRR depends positively on the wage premium, the employability premium, the share of time students devote to paid work and the average income tax rate, while it depends negatively on direct costs, study duration, the marginal tax rate and, to a lesser extent, the unemployment benefit replacement rate. Another set of simulations has shown

that moving the various IRR components to the boundary values of their respective cross-country distribution would lead to substantial changes in IRR. Policy makers may build on some of these results to design policies with the objective of stimulating incentives to invest in tertiary human capital.

However, if the policy targets the volume of investment in tertiary human capital rather than IRR *per se*, Oliveira *et al.* (2007) show that putting in place policies that increase returns to education is not the only way to go. They find that supply-side factors as well as financing constraints facing individual students also have an important role in determining the country-wide level of tertiary human capital investment. Their simulation results suggest that aligning the input and output flexibility as well as the accountability of tertiary education institutions on supply conditions observed in the best-performing countries in the OECD would lead to substantial increases in tertiary graduation rates. Some of the supply-side policies may also be seen as a necessary condition for the effectiveness of policies aimed at raising IRR: returns to education may well be substantial in a given country, but if the education system fails to send a clear signal as to how big these returns are, the investment in education may not materialise.

Notes

1. The relationship between incentives to invest and innate ability (when all other sources of individual heterogeneity are constant) is twofold: on the one hand, innate ability and received education are seen as complements in producing human capital; on the other hand, innate ability is deemed to be positively correlated with the opportunity cost of studying. Returns to investment in education for the more able will be, according to these two effects, respectively higher and lower than for the average individual. Higher discount rates due to impatience (distaste for schooling) or higher liquidity constraints will make the option of studying less attractive, for a given rate of return to education. In other words, returns should be higher to attract impatient students or financially constrained individuals. When ability and discount rates vary together, the endogeneity bias will be determined by the variance in ability relative to the variance in discount rates, as well as by the covariance of the two. For instance, when ability and discount rates are negatively correlated (typically through family background), marginal returns to education for the more able and, hence, their optimal level of schooling, are higher than for average individuals.
2. It remains controversial, however, whether the ability bias is rightly captured in these studies.
3. For instance, Blöndal *et al.* (2002) used the discount method to compute private and social rates of return for ten OECD countries in the 1999-2000 period. Psacharopoulos and Patrinos (1994) collect estimations from different studies based on the discount method encompassing more than 80 countries for periods ranging from the mid-1970s to the early 1990s.
4. The discount method and the Mincerian earnings equation differ not only in the extent to which they take into account costs of education, taxes and social benefits, but also because of different underlying assumptions on the life-cycle earnings profile (see Boarini and Strauss, 2007).
5. This choice is mainly due to the lack of reliable cross-country data on (the actual incidence of) students' work.
6. Previous empirical studies (Asplund and Pereira, 1999; Blöndal *et al.*, 2002; Harmon *et al.*, 2003; and Psacharopoulos and Patrinos, 2004) and the analysis in this paper show that premia differ across genders.
7. This sub-section draws on Strauss and de la Maisonneuve (2007), where the data sets, the choice and construction of variables and the econometric specification are discussed in detail. See also Strauss and de la Maisonneuve (2009).
8. It can be argued that an increased opportunity to work in a large plant could be an additional benefit of undertaking higher education, and thus this variable should not be controlled for. However, Strauss and de la Maisonneuve (2007) show that the correlation coefficient between educational attainment and the plant size is relatively small, suggesting that the possible associated endogeneity bias is also small.

9. It has to be borne in mind that the strong dispersion of wage premia across countries may reflect country-specific productivity differences between tertiary and upper-secondary degree holders, and also other factors, such as different scarcity rents on skilled labour and the degree of labour market regulation. In Portugal and Hungary high wage premia are more likely to reflect scarcity rents, whereas low degrees of labour market regulation seem to drive premia in the United Kingdom and the United States.

10. For instance, if only upper-secondary degree holders with good chances of finding a job participate in the labour market, the estimated employment probability of secondary-educated individuals will be biased upward and the employability premium associated with tertiary education will be underestimated.

11. As for the wage premia, the rationale to control for experience is strong when estimating the employment probabilities. However, approximating actual experience with potential experience would be more problematic in this context because the surveys provide no information on previous participation spells of currently inactive individuals. For this reason the variable age was retained instead.

12. Discouraged-worker effects are controlled for by excluding from the sample those individuals who, in any event, would have a very low probability of participating in the labour market. With this additional control, the estimates presented here are somewhere between the case where no adjustment is made for the selection bias and the one where all working age individuals are viewed as potential participants in the labour market. The variables of long-term unemployment and regional dummies are introduced only in estimations for European countries. The case for these variables has been tested through appropriate likelihood ratio tests. Countries where the regional dummies have a significant impact on the employment probabilities are Germany, Italy, Belgium, Spain, Greece and Austria. The underlying assumption is that workers do not migrate to regions where the probability of finding a job is higher, *i.e.* the region of residence is exogenous.

13. In countries where the selection bias is found to be non-existent, conditional employment probabilities are not significantly different from unconditional probabilities. Though the selection bias is found only for a subset of countries/years, drawing consistently on two-step estimates even when the selectivity bias is rejected allows for a unified framework warranting comparability across countries and years.

14. Some exceptions include Poland and women in Spain and Greece, where aggregate employability gaps are higher than estimates based on microeconomic data.

15. Limited time coverage of some countries (notably Switzerland, Hungary and Poland) might be a problem in this respect since, overall, the employability premium is found to fluctuate substantially over the cycle (see Boarini and Strauss, 2007). However, even large fluctuations in the employability premium have only a small impact on IRR (see the simulations around the employment premium in Boarini and Strauss, 2007).

16. See Boarini and Strauss, 2007, for the specific assumptions under these adjustments.

17. Data on average and marginal replacement rates are drawn from the OECD Benefits and Wages model.

18. Gross pension replacement rates are based on the new OECD Pensions model (OECD, 2005a); see Boarini and Strauss 2007 for details.

19. Due to data limitations, grants for living expenses cannot be computed for all countries and are therefore not accounted for in the baseline estimates of direct costs. In principle, grants for living expenses should be subtracted from private costs of education since upper-secondary degree holders who go to the labour market also bear living costs without receiving any transfer from the government. However, lacking relevant information for all countries under scrutiny, costs are only net of grants earmarked for tuition fees.

20. "Final" expenditure refers to the disbursement, while "initial" expenditure refers to the cost truly sustained by individuals, *i.e.* adjusted for public subsidies.

21. In principle it would have been possible, at least for labour market premia estimated on micro-data, to get a range of IRR by income decile (notably through quantile regressions). However, fiscal parameters and costs being solely available at aggregate level, the route of quantile regressions has not been pursued. Had this been done, it would not have been possible in any event to identify the causes of heterogeneity (*i.e.* individual ability *versus* higher quality of education, or high-rewarding field of studies) that remain unobservable in the data sets under use.

22. While these changes are numerically the same, they are quite different economically: a 1 percentage point increase in the employability premium from, say, 4 to 5 percentage points is more substantial than an increase in the wage premium from 40 to 41% or a 1% increase in the duration of studies.

23. These levels roughly correspond to the US wage premium for men and to the Hungarian wage premium for women. Hence, IRR in these two countries barely change in the simulation.

24. Both for men (3.8 percentage points) and for women (5.6 percentage points) the simulated employability premium is close to the 2001 levels observed in Finland. Note, however, that these values are not simulated for countries where this would move the employment probability for tertiary degree holders to values greater than one. For countries where the employment probability for upper-secondary degree holders is already above 0.962 for men and 0.944 for women (*e.g.* Luxembourg, the Netherlands and Switzerland), the simulated marginal effect is not 3.8 percentage points and 5.6 percentage points, respectively, but just the margin missing to one (*i.e.* to full employment of tertiary degree holders).

25. Average and marginal tax rates on replacement income are zero in this simulation to avoid negative values.

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Intergenerational Social Mobility in OECD Countries

by
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This paper assesses recent patterns of intergenerational social mobility across OECD countries and examines the role that public policies can play. It shows that the relationship between parental or socio-economic background and offspring educational and wage outcomes is positive and significant in practically all countries for which evidence is available. Intergenerational social mobility is measured by several different indicators, since no single indicator provides a complete picture. However, one pattern that emerges is of a group of countries, southern European countries and Luxembourg, which appears to rank as relatively immobile on most indicators, while another group, the Nordic countries, is found to be more mobile. Furthermore, public policies such as education and early childcare play a role in explaining observed differences in intergenerational social mobility across countries.

JEL classification: J60, J62, I20, H23, C20, C21

Keywords: intergenerational wage mobility, intergenerational education mobility, education, public policies

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This paper assesses recent patterns in intergenerational social mobility across OECD countries, examining the role that policies can play in affecting such mobility. Intergenerational social mobility refers to the relationship between the socio-economic status of parents and the status their children will attain as adults. A society can be more or less mobile depending on whether this relationship is, on average, looser or tighter: in a relatively immobile society an individual's wage, education or occupation will tend to be strongly related to those of his/her parents. Intergenerational mobility reflects a host of factors, including inherited traits, social norms and public policies that may influence the individual's willingness and ability to seize economic opportunities. These factors are difficult to unbundle precisely and, as regards norms and policies, to some extent reflect societal choices over institutional settings as well as differences in choices over redistribution and equity, which are likely to be valued differently across countries. Therefore, no "benchmark" mobility level can be identified in cross-country comparisons.

Nonetheless, removing policy-related obstacles to social mobility can be advocated on equity and efficiency grounds because it can improve equality of economic opportunities and the way a society allocates human resources. Promoting intergenerational social mobility means providing individuals with the same opportunities *ex ante*, even though it does not imply that all individuals should achieve the same outcomes *ex post*. Furthermore, policies that affect social mobility are closely related to growth. The ability of an economy to allocate human resources to their best use can have important effects on economic performance. However, trade-offs can exist between policies that remove obstacles to social mobility and those that strengthen other drivers of growth. Therefore, understanding the role played by public policies *vis-à-vis* social mobility can help design policies that enhance equality of opportunity without adversely effecting economic growth. This could even enhance growth and equality of economic opportunities across generations.

The socio-economic status of parents can influence that of their children in two main ways: directly by affecting their labour productivity and labour market attachment and indirectly by facilitating their success on the labour market by other means (*e.g.* by the transmission of social norms such as work ethic or social networks). In turn, labour productivity of children is, to a large extent, determined by parents' investment in their human capital and children's ability to seize educational opportunities. One empirical challenge is to separate the direct productivity channel from indirect ones. Arguably, both can be influenced by public policies, *e.g.* education, redistributive and labour, or product market policies.

Intergenerational transmission of social status is usually measured as "wage or income persistence", *i.e.* the fraction of parental income or wages reflected in their offspring's income or wages. Measuring and comparing wage or income persistence across countries is made difficult by the lack of comparable cross-country data, especially of parents. Against this background, and given that education is a key transmission mechanism in intergenerational social mobility and matching skills with societal needs, this paper focuses

primarily on the role of education as a driver of mobility across generations. Its main contribution is to provide comparable estimates of intergenerational wage and educational mobility across OECD countries, focusing on the following concepts of mobility:

- The influence of parental background, as measured by educational achievement of parents, on wages and educational attainment of various cohorts of adults for 14 European OECD countries.
- The influence of parental background, as measured by a composite index of their socio-economic status, on cognitive achievements of 15-year-old students in 30 OECD countries.

The analysis draws on existing and new evidence from two main sources of individual-level information: wage and education mobility, using the 2005 Survey of Income and Living Conditions (SILC) poverty module of Eurostat survey data; and the influence of parental background on a teenager's cognitive achievement, using the 2006 OECD Programme for International Student Assessment (PISA) survey data. Though none of these concepts of mobility refers to intergenerational transmission of wages proper, the estimated persistence/mobility measures will be called "wage persistence/mobility" and "education persistence/mobility", respectively.

The paper is organised as follows. Section 1 outlines main findings. Section 2 describes the linkages between family background and wage and education outcomes of individuals, explaining the role of education in determining wage mobility. Section 3 analyses the extent of intergenerational wage and educational mobility across those OECD countries for which data are available. Finally, in light of these mobility patterns, Section 4 uses the same data sources to investigate the cross-country association between a range of public policies (including education, redistributive and labour, and product market) and social mobility and equality of opportunity across generations. Suggestive evidence is provided that the main channel through which policies may influence social mobility is via the link between cross-sectional inequality and intergenerational wage mobility.

1. Main findings

1.1. Mobility patterns

In this study intergenerational social mobility is measured by several different indicators (*e.g.* wage persistence, secondary and post-secondary education persistence). However, given the complex nature of social mobility, these indicators do not necessarily provide the same cross-country ranking, suggesting that no single indicator provides a complete picture.

- The influence of parental background on individual earnings varies widely across OECD countries for which estimates are available. Low mobility across generations, as measured by a close link between parents' and children's earnings, is particularly pronounced in the United Kingdom, Italy, the United States and France, while mobility is higher in the Nordic countries, Australia and Canada.
- Across European OECD countries covered by the analysis, there is a substantial wage premium associated with growing up in a higher-educated family and a penalty with growing up in a less-educated family, even after controlling for a number of individual characteristics. The premium and penalty are particularly large in southern European countries, the United Kingdom, Luxembourg and Ireland (a premium of 20% and penalty of

16% or more). In general, wage persistence across generations, measured as the difference between the wage premium and penalty, is slightly stronger for sons than for daughters.

- The influence of parental socio-economic status on student achievement in secondary education also differs across OECD countries. It is particularly strong in the United States, France and Belgium, while weaker in some Nordic countries, Korea and Canada. In over half of the OECD countries, including all the large continental European ones, student cognitive skills are more strongly influenced by the average socio-economic status of parents of other students in the same school, *i.e.* the schools' average socio-economic environment, than by their own parents' socio-economic status.
- Inequalities in secondary cognitive skills are likely to translate into inequalities in post-secondary educational achievement and subsequent wage inequality in the labour market. Indeed, in European OECD countries, students from a higher-educated family are more likely to achieve tertiary education, while there is a probability penalty associated with growing up in a less-educated family. The increase in the probability of achieving tertiary education is particularly strong in Luxembourg, Italy, Finland and Denmark, where it is 30 percentage points higher for a son whose father had tertiary education than for a son whose father had only upper-secondary education. Furthermore, transmitted inequalities in education are positively associated across countries with inequalities in wages.
- In all European OECD countries covered by the analysis, the probability of achieving below secondary education is on average 18 percentage points higher for children whose father had below upper-secondary education compared with those whose father had upper-secondary education. Conversely, the probability of achieving below upper-secondary education decreases on average by 10 percentage points for offspring of tertiary educated fathers compared with children whose father had upper-secondary education.

1.2. Intergenerational mobility and inequality

- Intergenerational social persistence, as measured by a close link between parental education achievement and children's wages, is correlated across countries with cross-sectional inequality and poverty. The association between parental socio-economic status and teenager cognitive achievement is stronger in countries with a greater share of children living under the poverty line or lacking basic material resources.

1.3. Policies and mobility

- Higher enrolment in child care and early childhood education correlates with a lower influence of parental socio-economic background on teenager cognitive skills, suggesting a positive effect on social mobility. These policies are likely to be most efficient when targeted at children from low-income and/or second-language families.
- Practices that group students into different programmes or curricula according to proficiency level, for instance, early tracking and ability grouping within classes, correlate with a stronger influence of parental socio-economic background on teenager cognitive skills. This reflects a stronger influence of the school socio-economic environment on a student's performance in the case of early tracking practices.
- By contrast, a better matching of school resources with needs, as well as a steeper progression in teachers' wages over their career, are associated with a lower influence of parental background on student achievement, possibly by attracting experienced

teachers to disadvantaged areas. Likewise, a larger share of qualified teachers correlates with lower inequalities transmitted by family background.

- Evidence suggests that increasing the social mix within schools increases performance of disadvantaged students with neutral or in some cases positive effects on overall performance. Thus, policies aimed at encouraging such a mix in neighbourhoods may mitigate inequalities.
- There is suggestive evidence that universal government-supported loan systems for tertiary education are associated with higher social mobility, as measured by the probability of the offspring of disadvantaged families completing tertiary education. In countries lacking such systems, financial constraints could be an obstacle to achieving tertiary education for students from disadvantaged backgrounds.
- More progressive income taxation and higher short-term unemployment benefits are associated with a looser link between parental background and teenager cognitive skills and wages. This may indicate that well-targeted redistributive and income support policies lower cross-sectional income inequality and poverty rates.

2. Determinants of intergenerational social mobility

2.1. The linkages between parental background and offspring outcomes

Intergenerational social mobility can be measured by income, education, occupation or social class. Economic research has traditionally focused on some measure of income or wages.[1] Studies assessing the association between parent and offspring income focus on pairs of fathers and sons. Ideally, income should be measured by a household's disposable income, as this most directly influences the standard of living of individuals (*e.g.* Chadwick and Solon, 2002; Solon, 2004; Lee and Solon, 2006). In practice, accurate measurement is difficult, as it should take into account the structure of the household, the extent of female participation in the labour market and the different sources of income (*e.g.* earnings, assets, welfare). Therefore, most studies use some measure of wages (Box 1). The extent to which the offspring's wage levels reflect those of the parents (the so-called "intergenerational wage elasticity") is taken as a measure of wage persistence across generations, or lack of intergenerational wage mobility. The higher this elasticity, the lower is intergenerational wage mobility. However, one difficulty in adopting this approach in a cross-country context is that comparable information on wages of parents is seldom available.

Parental background can influence offspring wages (Figure 1) in very general terms, by boosting both offspring labour productivity and successful insertion in the labour market. One way children's productivity, and hence future income, can be enhanced is through the ability of parents to invest in their offspring's human capital. However, wealth and assets passed on from one generation to another, the inheritance of traits that are important for economic success, such as propensities to undertake education, work ethics and risk-related behaviours, as well as local conditions such as growing up in advantaged neighbourhoods, are other important factors (for an overview see d'Addio, 2007).

One empirical challenge is to separate the direct productivity channel from indirect labour market ones. Another more fundamental challenge is to empirically isolate the effect of parental background ("nurture") from that of genetic inheritance of abilities ("nature") on individuals' wages and educational achievement. In general, as in this study, estimates of the impact of parental background on individuals' wages and educational achievement combine these two effects. The relative importance of nature *versus* nurture

Box 1. **Concepts in intergenerational social mobility**

Measures of intergenerational income mobility are often based on empirical estimation of the intergenerational income elasticity, β, which measures the extent to which offspring income levels, Y_i, reflect those of their parents, Y_i^P, that is:

$$\ln Y_i = \alpha + \beta \cdot \ln Y_i^P + \varepsilon_i \quad .$$

This estimated elasticity is a measure of average intergenerational income persistence. A low value implies that the link between parent and offspring incomes is relatively weak, while a high value implies a relatively strong link. An alternative measure is the partial correlation between parent and offspring incomes, which adjusts for potential differences in the variance of income between the two generations.

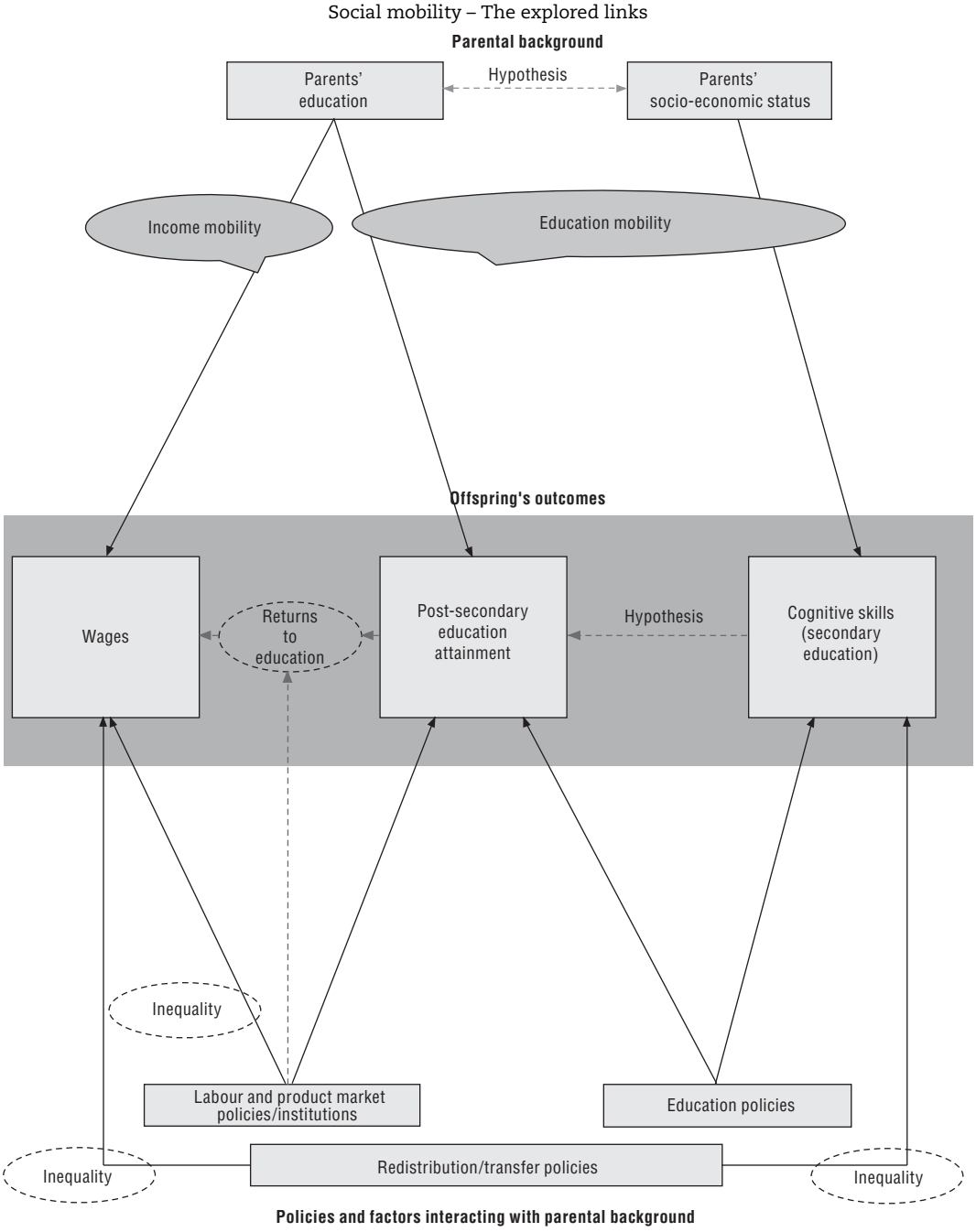
Theoretical studies of intergenerational mobility regard long-run permanent disposable income as the most appropriate income concept (*e.g.* Goldberger, 1989; Chadwick and Solon, 2002; Solon, 2004; Lee and Solon, 2006; Haider and Solon, 2006). But basing estimates of persistence across generations on current wages raises some key issues (Solon, 2002). First, measuring permanent income/wages of parents with error leads to inconsistent estimates, causing an underestimation of the true intergenerational elasticity. Second, using current wages of offspring as a proxy for lifetime income can also cause a bias, in particular when looking at individuals at the beginning of their careers (Haider and Solon, 2006). Studies based on such measures of offspring wages tend to find lower elasticity estimates than studies measuring wages further along their careers or life cycles. To overcome these problems, many studies average both parental and offspring wages over several years or measure offspring wages after a few years' experience in the labour market.

Educational persistence is often measured by the correlation between years of schooling or educational achievement of parents and their offspring. However, basing educational persistence on years of schooling assumes that the impact on human capital of an additional year of schooling is the same across generations, and that years of schooling affect human capital in the same way across countries. These problems are overcome by studies that assess educational mobility in terms of qualification or literacy levels achieved, as measured, for instance, by the harmonised cross-country ISCED classification (*e.g.* Chevalier *et al.*, 2007) or by test scores of cognitive skills (OECD, 2007a; Hertz *et al.*, 2007).

in explaining intergenerational social mobility is far from established (*e.g.* Sacerdote, 2002; Bowles *et al.*, 2002; Plug and Vijverberg, 2005). However, to the extent that genetic inheritability of ability does not vary systematically across countries, such heritability should not influence cross-country variation in wage or educational mobility.

An important part of wage persistence across generations is driven by the effect of parental background on cognitive skills acquired by their children in formal (and informal) education (which influences the offspring's productivity). This includes secondary education and post-secondary education (Figure 1 and Box 2). Indeed, recent studies show that there is a clear connection between intergenerational wage mobility and intergenerational educational mobility, although educational mobility cannot account for all the estimated persistence in incomes (Blanden, 2008a; Blanden *et al.*, 2005; Solon, 2004). Educational differences tend to persist across generations, and differences in such persistence explain a large share of the cross-country variation of intergenerational wage correlations (*e.g.* Solon, 2004; Blanden *et al.*, 2006; Blanden *et al.*, 2005; d'Addio, 2007). The extent to which education is responsible for intergenerational persistence in wages depends on how strongly

Figure 1. **Some links between parental background and their offspring's outcomes**



educational achievement is tied to family background, that is, the degree of persistence in education. Of course, the intergenerational wage link is also affected by the returns to education in the labour market (*e.g.* Solon, 2004; d'Addio, 2007).[2] It is likely that inequalities in cognitive skills acquired in secondary education translate into inequalities in achieving post-secondary education and into wages via the returns to education in the labour market.

Box 2. **Education as a determinant of intergenerational social mobility**

Several recent studies analyse the link between intergenerational persistence in education and income (*e.g.* Solon, 2004). In these studies the offspring's investment in education, which drives intergenerational income mobility, depends on family income.

Educational attainment varies with parental income due to both differing endowments (propensity to undertake education and possession of a work ethic) and differing private investment in education across families. If all families had full access to perfect capital markets, only inheritable traits would influence mobility (Becker and Tomes, 1979). But if parents cannot borrow against their children's future earnings to finance their education, liquidity-constrained parents will invest sub-optimally in their children's education (Becker and Tomes, 1986; Grawe and Mulligan, 2002). Additionally, parental investment in education increases in the return to human capital investment, since parents are more inclined to invest in their children's education when the payoff is higher. Thus, in the presence of financial constraints, wealthier families tend to invest more in their children's human capital, and such investment is increasing in labour market returns (Solon, 2004).

Some of these studies suggest that government spending on education can increase intergenerational mobility (Solon, 2004; Mayer and Lopoo, 2008). Progressive public investment in education can offset sub-optimal parental investment in education, to the extent that the offspring of liquidity-constrained parents benefit relatively more from these public programmes. A recent study for the United States shows that intergenerational mobility is greater in high-spending states compared with low-spending states (Mayer and Lopoo, 2008).

Persistence in wages across generations also appears to be positively associated across countries with measures of inequality, *i.e.* of the dispersion of parental backgrounds (see below and d'Addio, 2007, for an overview). Although causality between intra- and intergenerational persistence of inequality is far from established, it is possible that redistributive policies and institutions that narrow the gap between current incomes and/or wages of parents could also mitigate the influence of parental background on wages and educational outcomes of their offspring.

The empirical approach developed in the remainder of this paper has been partly shaped by the considerations above. The analysis of wage mobility measures parental background by fathers' education and their offspring's incomes as gross hourly wages.[3] Basing the estimation of persistence on gross hourly wages implies that the persistence measure reflect the impact of parental education on productivity. While, basing persistence estimates on monthly or annual wages would, in addition to the productivity effect, capture the labour supply decision, *i.e.* the decisions on working hours.

The study of wage mobility is supplemented by the analysis of educational mobility for teenagers (with parental background measured by a broad index of the family's socio-economic status and educational outcomes measured by PISA test scores) and adults (with parental background measured by father's education and offspring educational outcome measured by educational attainment). Finally, the analysis of policy influences on wage and educational mobility focuses on both education and other policies that are likely to affect cross-sectional inequality.

3. Intergenerational social mobility patterns

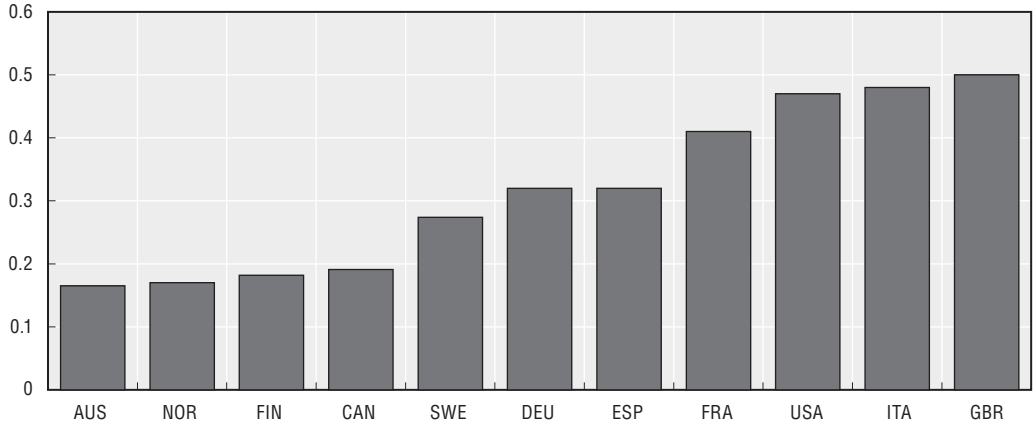
3.1. *Cross-country patterns in intergenerational income mobility*

3.1.1. *Intergenerational income persistence is significant in all OECD countries*

The relationship between socio-economic status of parents and their offspring is positive and significant in practically all countries for which evidence is available, and for many different aspects of social status (*e.g.* Hertz *et al.,* 2007; Corak, 2004). International comparisons of intergenerational income persistence are relatively common (*e.g.* Solon, 2002; Corak, 2006; d'Addio, 2007). However, these comparisons can be invalid because different studies use different variable definitions, samples, estimation methods and time periods.

Taking the available estimates at face value, cross-country comparison of intergenerational income elasticities based on (various measures of) earnings for pairs of fathers and sons suggests that persistence is higher in the United Kingdom, Italy, the United States and France among the OECD countries for which comparable estimates are available (*e.g.* Corak, 2006; Blanden, 2008b).[4] In these countries at least, 40% of the economic advantage high-earning parents have over low-earning parents is passed on to the next generation (Figure 2). By contrast, intergenerational persistence is comparatively low in the Nordic countries, Australia and Canada, with less than 20% of the earnings advantage passed from parent to offspring.

Figure 2. **Intergenerational earnings elasticity,[1] estimates from various studies: selected OECD countries**

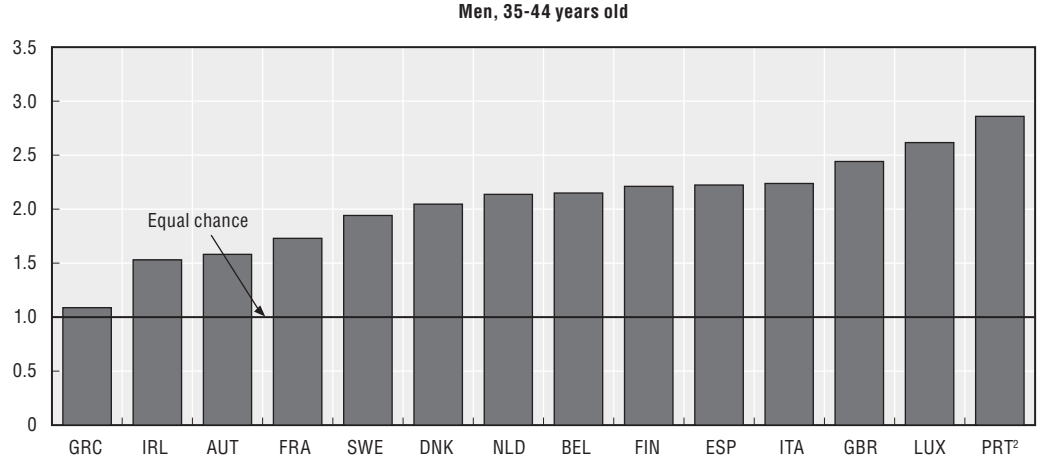


1. The height of each bar measures the extent to which son's earnings levels reflect those of their fathers. The estimates are the best point estimate of the intergenerational earnings elasticity resulting from an extensive meta-analysis carried out by Corak (2006) and supplemented with additional countries from d'Addio (2007). The choice of empirical estimates in this meta-analysis is motivated by the fact that they are based on studies that are similar in their estimation technique, sample and variable definitions. The higher the value, the greater is the persistence of earnings across generations, thus the lower is the intergenerational earnings mobility.

Source: D'Addio (2007).

These patterns of intergenerational persistence are partly confirmed by descriptive evidence based on new comparable data for European OECD countries, which allow systematic comparison of sons' wages to the educational attainment of fathers (see Causa *et al.,* 2009, and Box 3). In all the countries covered, a son is much more likely to be in the top wage quartile if his father had achieved tertiary education compared with a son whose father had only basic (below upper-secondary) education, particularly in Portugal, Luxembourg and the United Kingdom (Figure 3).[5]

Figure 3. **Ratio of the chance of being in the top wage quartile for sons of higher-educated *vs.* lower-educated fathers:[1] Selected European OECD countries**



Note: Germany is not included in this figure as there is a problem with the representativeness of the German sample along the education dimension.

1. This figure shows the ratio of two conditional probabilities. It measures the ratio between the probability to end up in the top wage quartile given that the son's father had achieved tertiary education and the probability to end up in the top wage quartile given that the son's father had achieved less than upper-secondary education. Probabilities are defined as simple frequency measures. Fathers' educational achievement is a proxy for parental background or wages.
2. 25-34 years old for Portugal.

Source: OECD calculations based on the 2005 *EU-SILC Database*.

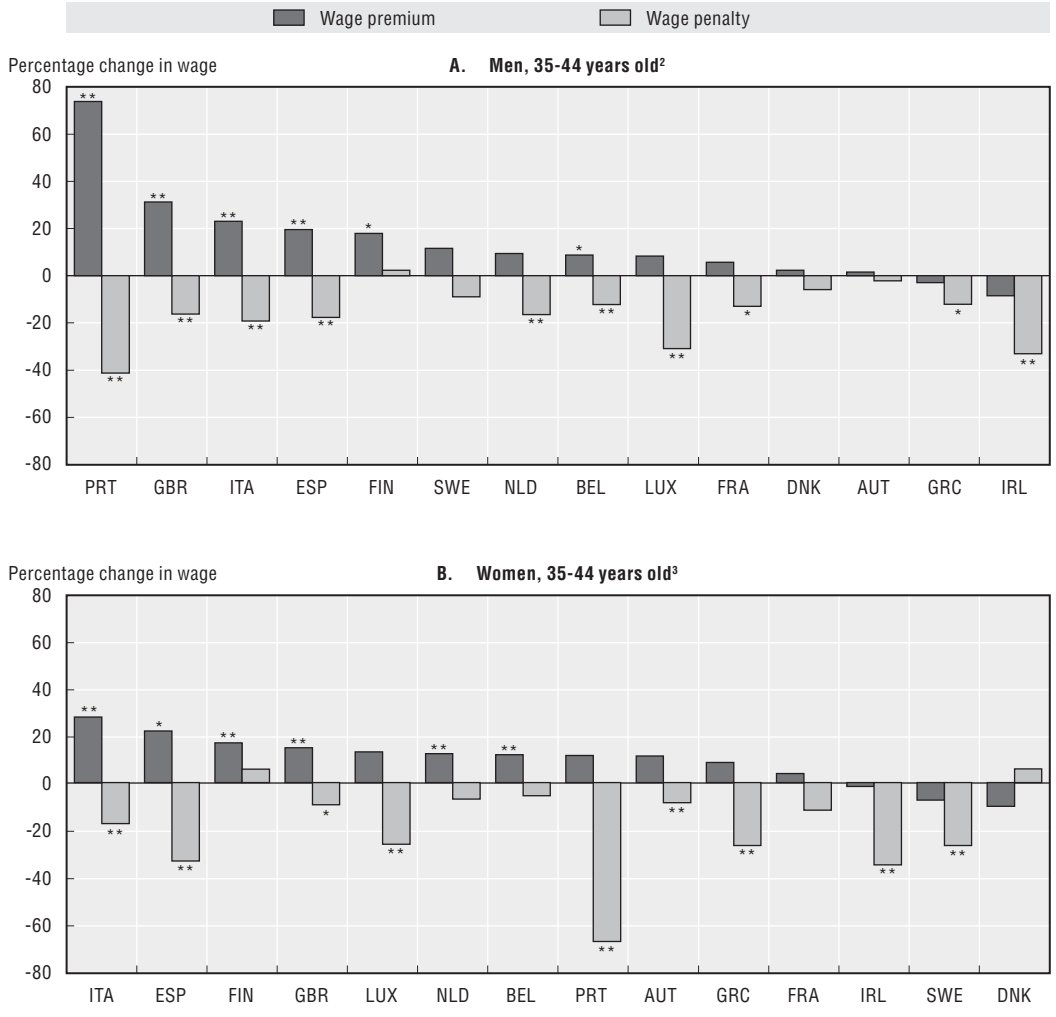
Box 3. **Measuring the link between parental educational background and offspring wages**

The analysis in Causa *et al.* (2009) is based on the 2005 module on the intergenerational transmission of poverty of the *EU-SILC Household Database*. This poverty module contains retrospective information on parental background when the respondent was a teenager. This information is comparable across European OECD countries and includes family composition, age, educational qualification level, activity status and occupation of mother and father, as well as an indicator of financial distress conditions. However, information on parents' wages is lacking.

The approach taken in this study is to proxy parental background by the highest educational qualification level achieved by the father according to the International Standard Classification of Education (ISCED). One advantage of using father's education as a proxy for his income is that education is likely to be a more permanent feature than current wages, while being highly correlated with wages in most countries. The offspring's income concept refers to gross hourly wages and salaries paid in cash for time worked or for time not worked, such as holidays, as well as additional payments (*e.g.* overtime payments, bonuses). Henceforth, this will be referred to as wages. The results focus on two cohorts of offspring (35-44 and 45-54) and their parents. The youngest cohort (25-34 years old) is excluded because of the potential difficulties associated with measuring permanent wages/incomes at young ages, as discussed in Box 1, as well as with ensuring that the individuals under consideration have reached their desired educational level.

To explore more fully this descriptive evidence through regression analysis, it was assumed that individual wage prospects depend on fathers' educational attainment in two ways: through the direct transmission of factors that affect the economic success of offspring; and through influencing their offspring's educational attainment (see Causa *et al.*, 2009, and Box 4). The first channel, that is, estimates of parameter *a* in equation [1], Box 4, captures the transmission of wealth, work ethic and social norms or networks that

Figure 4. **Wage premium and penalty due to paternal education levels:**[1] **Selected European OECD countries**



Notes: * denotes statistically significant at 10% at least.
** denotes statistically significant at 5% at least.
Germany is not included in this figure, as there is a problem with the representativeness of the German sample along the education dimension.

1. The figure shows the estimated percentage change in wages of the offspring depending on their parental background measured by father's highest education level. The wage premium is the increase in the offspring's wage of having a father with tertiary education relative to an offspring whose father had upper-secondary education. The wage penalty is the decrease in the offspring's wage of having a father with less than upper-secondary education relative to an offspring whose father had upper-secondary education. Fathers' educational achievement is a proxy for parental background or wage.
2. Based on OLS wage regression model.
3. Based on wage regression model with selection into paid employment (Heckman full maximum likelihood estimation).

Source: OECD calculations based on the 2005 *EU-SILC Database*.

Box 4. **The influence of parental background on offspring wages**

The empirical strategy for assessing the influence of parental background on offspring wages assumes that gross hourly wages (W_i) depend on both the offspring's effort or educational attainment (EC_i) and the influence of father's educational attainment (E_i) (for details, see Causa *et al.*, 2009):

$$\ln W_i = k + a \cdot E_i + b \cdot EC_i + \varepsilon_{i1}, \quad [1]$$

where *a* measures the strength of the direct influence of the father's educational attainment on wages (*e.g.* through the transmission of social norms, work ethic, social networks and other factors facilitating the economic success of children) and *b* the offspring's labour market returns to their educational attainment.

In turn, the offspring's educational attainment is assumed to depend on their fathers' educational attainment, reflecting, for instance, the ability and willingness of fathers to invest in their offspring's human capital as well as other inheritable factors affecting the ability of their children to seize educational opportunities, such that:

$$EC_i = j + d \cdot E_i + \varepsilon_{i2} \cdot \quad [2]$$

Combining these two equations yields,

$$\ln W_i = e + f \cdot E_i + \varepsilon_{i3}, \quad [3]$$

where $f = (a + bd)$ captures the total effect of a father's educational attainment on individual wages. This effect is decomposed in a direct effect on wages (*a*) and an indirect effect through education (*bd*), which in turn consists of the returns to offspring's own education (*b*) and the influence of father's educational attainment on their offspring's educational attainment (*d*).

In the first stage, the total effect of a fathers educational attainment on individual wages, equation [3], is estimated for various cohorts of men and women. The estimation controls for "Mincerian" individual characteristics such as living in an urban/rural area and migrant and marital/cohabitant status. The results are robust to inclusion of age and experience.[1] Ordinary least squares (OLS) estimates of equations [1] and [3] may be biased due to non-random selection into employment, since it is likely that those who are not working constitute a self-selected sample, particularly women who would earn low wages. To overcome this selection problem, this study uses the Heckman sample selection bias estimator for women and OLS for men (*e.g.* Heckman, 1976). However, results for women remain broadly the same under OLS or Heckman estimation techniques.

In the second stage, estimation of equation [1], offspring educational attainment is introduced as an explanatory variable in order to find out whether fathers' educational attainment mainly influences their offspring's wages through influence on education or if it has a direct effect on wages, over and above the effect on education.[2]

In the third stage, the influence of fathers' educational attainment on that of their offspring is explicitly estimated (equation [2]). The empirical results are obtained by estimating an Ordered Probit model, in which observed educational outcomes of individuals (EC_i) are assumed to be driven by an underlying continuous variable measuring their "propensity to achieve education". This underlying variable is assumed to be determined by their father's educational attainment (E_i) and a number of individual characteristics. The results suggest that in all European OECD countries fathers' educational attainment influences that of their offspring (Causa *et al.*, 2009).

1. In "Mincerian" wage equations, age, experience and experience squared are standard controls. Life-cycle effects are not considered in the final estimates because they are not statistically significant in the current setting, due to weak identification within narrowly defined age groups (or cohorts).
2. It is possible that there is a potential endogeneity of own education in this specification due to unobserved variables such as ability and/or motivation, which may be correlated with both education and wages. This would result in an upward bias of the influence of own education on wages. Usually, instrumental variable (IV) estimation is used to address this problem, but it is often difficult to find appropriate instruments, and weak instruments may bias the results further. Indeed, studies using (IV) estimations often find even higher estimates of the influence of education on wages than OLS, which suggests that measurement error in the education variable might be a more serious problem than endogeneity (*e.g.* Card, 2001).

facilitate successful labour market insertion. The second channel, *i.e.* estimates of parameter *b* in equation [1], Box 4, captures access to education, as well as the individual propensity to acquire education and genetically transmitted ability to learn, which affect an individual's productivity (*e.g.* Bourguignon *et al.,* 2003). As a first step in the analysis, Figure 4 reports estimates of the overall effect of a father's educational attainment on offspring wages (estimates of parameter *f* in equation [3], Box 4), with no distinction between these channels.

3.1.2. *Wage premium or penalty depending on father's educational attainment*

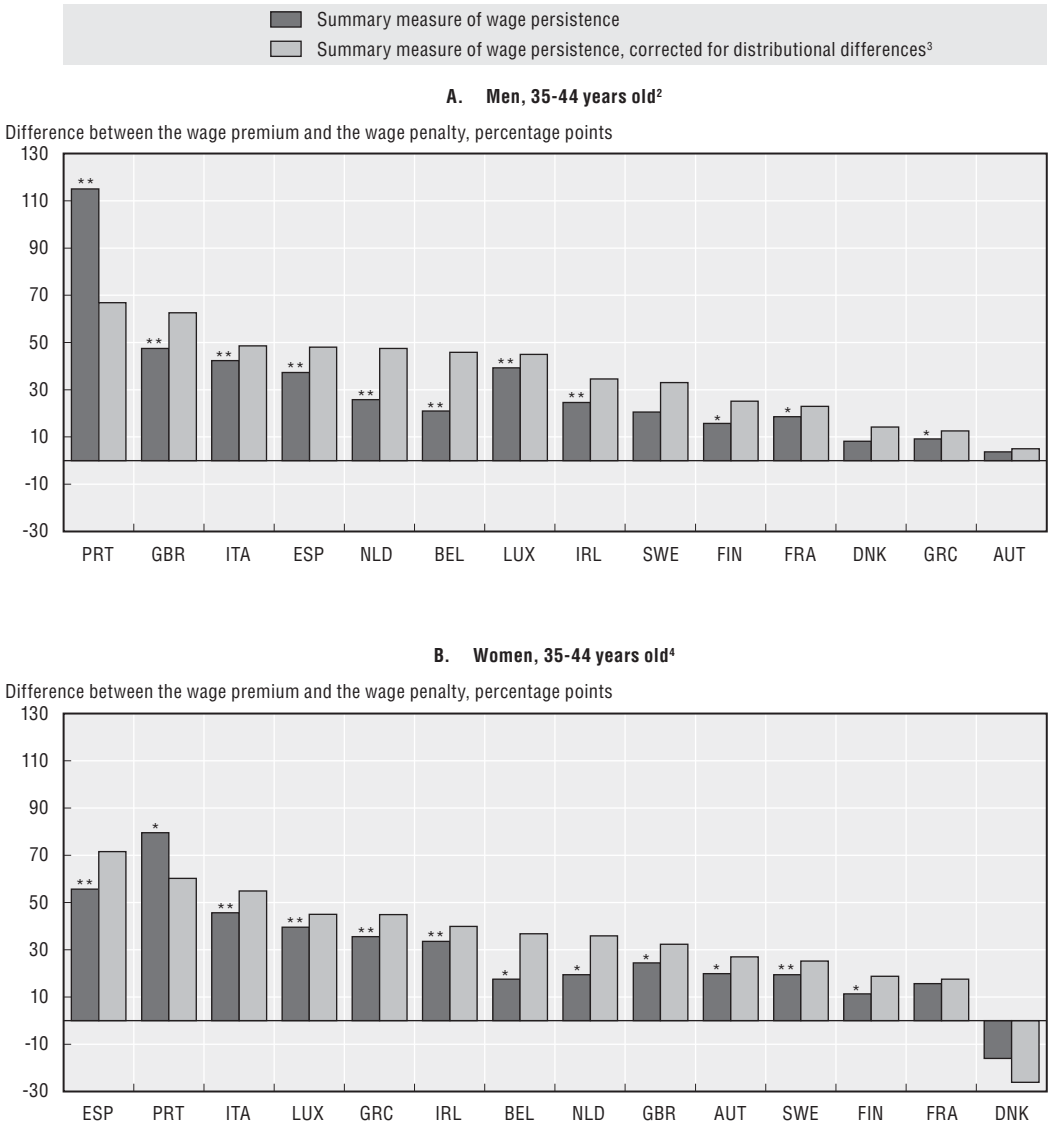
In all European OECD countries covered by the analysis, there is a positive wage premium (measured as the increase in gross hourly wages) for offspring of higher-educated fathers, while there is a penalty (measured as the decrease in gross hourly wages) for offspring of lower-educated fathers (Figure 4). The wage premium is particularly large in southern European OECD countries, the United Kingdom and Finland. In these countries, having a father with tertiary education raises sons' wages by some 20% or more compared with a son whose father had upper-secondary education. At the same time, the wage penalty of having a father with only basic education compared with a father with upper-secondary education appears to be high in the same countries, as well as in Luxembourg and Ireland. In these countries, the wage of a son whose father had below upper-secondary education falls short by more than 16% of the wage of a son whose father had upper-secondary education.[6] The influence of paternal background on daughters' wage premia is, in general, slightly lower than that of sons, yet still substantial. Moreover, for women, the average wage penalty of coming from a disadvantaged background is sometimes much higher than the premium of coming from an advantaged background.[7]

3.1.3. *Summary measure of persistence in wages*

One way of summarising the extent of wage persistence across generations is to measure the gap between the estimated wage premium and the penalty of having a tertiary-educated or below upper-secondary educated father, respectively. A greater gap would imply stronger persistence in wages over generations. According to this measure, intergenerational wage persistence for sons is particularly strong in some southern European countries and in the United Kingdom, while it is lower in some Nordic countries, Austria and Greece (Figure 5). The cross-country ranking of persistence in wages for women is similar to that of men. However, these patterns could be influenced by distributional differences in fathers' educational attainment and individuals' wages, since wider distributions of individual wages (relative to parental background) could mechanically translate into higher persistence estimates. One way of accounting for this is to adjust the estimated wage persistence for cross-country differences in the dispersion of father's education and offspring's wages. The cross-country ranking presented in Figure 5 remains fairly unchanged to this adjustment (the rank correlation between non-standardised and standardised persistence measures is 0.96). The remainder of the discussion in this study refers to the standardised measure of wage persistence.

It is difficult to compare this measure of persistence in wages over generations with existing estimates of the "intergenerational elasticity of income" reported in Figure 1 because the proxy used for parental background in this study is different from what is commonly used (some measure of fathers' wage or income). Even so, the findings in this study are qualitatively in line with existing evidence for pairs of fathers and sons.[8] The

Figure 5. **Summary measure of wage persistence levels:**[1]
Selected European OECD countries



Notes: * denotes statistically significant at 10% at least.
** denotes statistically significant at 5% at least.
Germany is not included in this figure, as there is a problem with the representativeness of the German sample along the education dimension.

1. Wage persistence is measured as the distance or gap between the estimated wage premium and penalty. Thus, it measures the percentage increase in wages of an offspring having a father with tertiary education relative to an offspring having a father with below-upper secondary education. A larger number implies a larger gap, thus stronger persistence in wages or a higher degree of immobility over generations. Fathers' educational achievement is a proxy for parental background or wage.
2. Based on OLS wage regression model.
3. The summary measure of wage persistence, corrected for distributional differences, corresponds to the summary measure of wage persistence, multiplied by the ratio of the standard deviation of fathers' education to the standard deviation of sons' or daughters' gross hourly wage.
4. Based on wage regression model with selection into paid employment (Heckman full maximum likelihood estimation).

Source: OECD calculations based on the 2005 *EU-SILC Database*.

United Kingdom is estimated to have relatively low wage mobility, while some Nordic countries appear to be more mobile, as frequently found in previous empirical studies (*e.g.* d'Addio, 2007; Corak, 2006). However, there are some differences. For instance, France appears to be much less mobile in terms of the "intergenerational income elasticity" than on the basis of the influence of fathers' education on sons' wages, perhaps reflecting that fathers' education is not a good proxy for parental income in this country.

3.1.4. The role of education as a driver of persistence

As a further step in the analysis of wage persistence, an attempt was made to separate the direct influence of a father's educational attainment on their offspring's wages from the indirect effect going through their offspring's own educational attainment (*i.e.* estimation of the relative magnitudes of coefficients *a* and *b* in equation [1], Box 4). The resulting estimates suggest that parental background mainly influences offspring wages through their own educational attainment (*i.e.* by indirectly influencing offspring productivity) except in a few countries (the United Kingdom, Spain, Italy, Netherlands, Luxembourg and Ireland) where direct linkages appear to be more important than the indirect ones through education. More specifically, in most countries fathers' educational attainment (estimates of coefficient *a* in equation [1], Box 4) is no longer important (*i.e.* significant) in determining sons' wages once the sons' educational attainment is taken into account. This result is even more pronounced in the case of women (Causa *et al.*, 2009, for details). Thus, education is a key factor explaining persistence in wages across generations in many countries and policies providing equal opportunities in access to education are essential in enhancing social mobility.

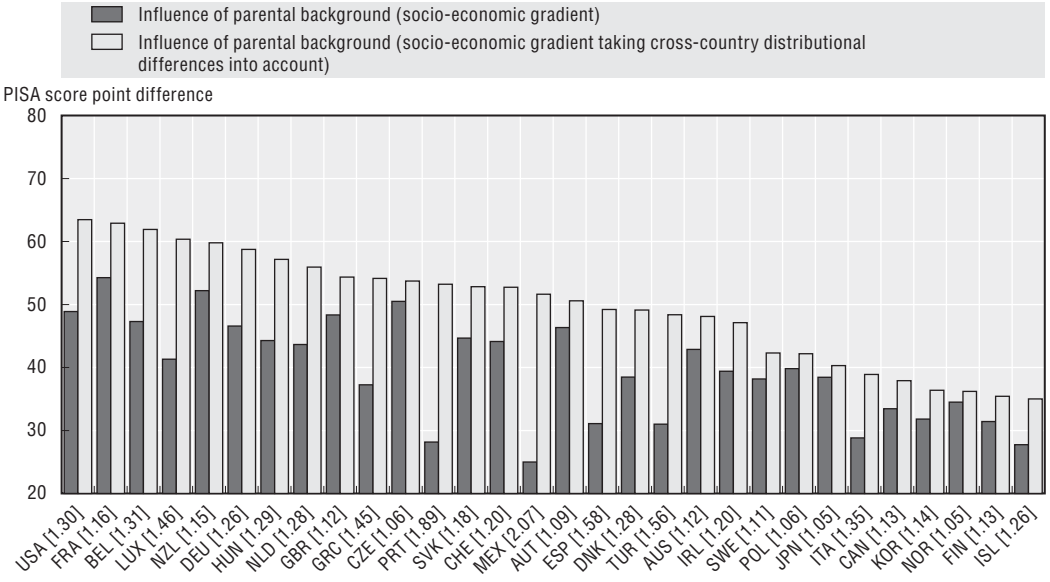
3.2. Cross-country patterns in intergenerational education mobility

Given that individuals' educational attainment appears to be a key driver of wages in European OECD countries, it is important to understand to what extent skills acquired in formal education, including secondary and post-secondary, are influenced by parental background. Moreover, differences in secondary educational achievement due to parental background may contribute to differences in post-secondary achievement which, in turn, can lead to persistence in wages. To this end, this section analyses cross-country patterns of intergenerational education persistence in secondary education for teenagers, followed by persistence patterns in post-secondary education for adults.

3.2.1. Parental background influences student achievement in secondary school

The extent to which parental background, measured by a broad index of socio-economic status of a student's family, influences student cognitive performance at the level of secondary education differs substantially across OECD countries (Figure 6). Henceforth, when discussing persistence in secondary educational achievement, this refers to the estimated influence of this index on a student's performance on the PISA test score (see Causa and Chapuis, 2009, and Box 5 for details). As in the case of wage persistence, the estimates cannot distinguish between effects of parental background and genetically inheritable factors. France, New Zealand, the Czech Republic, United States and United Kingdom are among the countries where persistence is highest according to this metric, while persistence is relatively low in Iceland, Finland, Southern European countries, Mexico and Turkey.[9]

Figure 6. **The influence of parental background on secondary students' achievement**[1]



Notes: Socio-economic gradient: change in PISA science score due to an improvement of one international standard deviation in the PISA index of student socio-economic background. Socio-economic gradient taking cross-country distributional differences into account: change in PISA science score due to an improvement of one country-specific, inter-quartile change in the PISA index of student socio-economic background.
Data in brackets are values of the difference between the highest and the lowest quartiles of the country-specific distribution of the PISA index of economic, social and cultural status, calculated at the student-level.

1. Regression of students' PISA science performance scores on their PISA economic, social and cultural status (ESCS), a broad indicator of family's socio-economic background. Country-by-country least-squares regressions weighted by students' sampling probability. Robust standard errors adjusted for clustering at the school level. Regressions for Italy include regional fixed effects.

Source: OECD calculations based on the 2006 *OECD PISA Database*.

The variation within a country in the distribution of student socio-economic status (parental background) may matter for the overall impact of background on student achievement (OECD, 2007a; OECD, 2004). The cross-country patterns of intergenerational educational persistence change considerably after taking country differences in the distribution of socio-economic status into account (Figure 6).[10] In countries like Mexico, Portugal, Luxembourg, Spain and Turkey, where the dispersion in student socio-economic background is wide, even a relatively mild influence of parental background on their achievement can lead to a large overall difference. After adjusting for the country-specific distribution of socio-economic status, the United States, France and Belgium are countries where parental background has the greatest influence on student achievement. The remainder of the discussion of persistence in secondary education takes these distributional differences across countries into account.

3.2.2. In many countries the school environment has a large influence on student achievement

Using a similar approach to PISA 2007 (OECD, 2007a), Figure 7 decomposes the overall influence of parental background on student achievement into an individual background effect ("within-school" effect) and a school environment effect ("between-school" effect).

Box 5. **The influence of parental background on student achievement in secondary education**

The empirical analysis in Causa and Chapuis (2009) is based on the *2006 PISA Survey* which collects a cross-country, comparable microeconomic dataset on student achievement (for details see OECD, 2007a; OECD, 2005a, b). PISA assesses the skills of students approaching the end of compulsory education in 67 countries, including all OECD countries. PISA 2006 measures mathematical, scientific and reading literacy, as well as problem-solving skills of students in each participating country. The target population is 15-year-old students in each country, regardless of the grade they currently achieve and independent of how many years of schooling are foreseen for 15-year-olds by the national school systems. The main focus of the *PISA 2006 Study* is on science literacy, with about 70% of the testing time devoted to this. Given the very high correlation among science, mathematics and reading scores, the analysis in this study focuses on those for science. OECD (2007a) points to the robustness of country-specific and cross-country empirical assessments to the use of either score. PISA scores have an OECD mean of 500 points and a standard deviation of 100 points.

Equity in student achievement is defined by the concept of equality of opportunity (Roemer, 1998, 2004), according to which educational achievement should not reflect circumstances that are beyond a person's control, such as family socio-economic background. The empirical counterpart to this concept is to estimate the so-called "socio-economic gradient", which measures how strongly student educational achievement, measured by PISA test scores, depends on the socio-economic background of the students' families. Specifically, the analysis uses the Index of Economic, Social, and Cultural Status (ESCS) provided by PISA as the measure of parental background.

The PISA ESCS index is intended to capture a range of aspects of a student's family and home background. It is explicitly created in a comparative perspective and with the goal of minimising potential biases arising as a result of cross-country heterogeneity. The student scores on the index are factor scores derived from a Principal Component Analysis which are standardised to have an OECD mean of zero and a standard deviation of one. Thus, the size of the achievement difference between students with high and low values on the ESCS index provides a measure of how fair and inclusive each school system is: the smaller the difference, the more equal are educational opportunities.

In the baseline empirical model the student-level score is regressed upon his or her family socio-economic background:

$$Y_{isc} = \alpha_{1c} + \beta_{1c} \cdot F_{isc} + \varepsilon_{isc}, \qquad [1]$$

where index i refers to individual, s to school and c to country; Y_{isc} denotes the student science test score, F_{isc} denotes parental background as measured by the ESCS index; ε_{isc} an error term; and β refers to the influence of parental background on student achievement (*i.e.* the socio-economic gradient). Baseline estimations can be enriched to control for a number of individual factors (such as gender, migration and language spoken at home) and school factors (location, resources, size, ownership and funding), allowing comparison of the "gross" and "net" impact of family background on student performance. The estimates take into account the hierarchical and sampling structure of the PISA dataset; specifically, they are based on a clustering-robust linear regression technique, which does not require that individual observations be independent within schools, but only that they be independent across schools (see Causa and Chapuis, 2009, for details). In addition, probability weighting is used to reflect differing sampling probabilities across students within countries.

Box 5. **The influence of parental background on student achievement in secondary education** *(cont.)*

The influence of parental background on student performance in secondary education can be divided into two parts, the "individual background" effect (F_{isc}) and the "school environment" effect ($\overline{F}_{sc}$), defined as the weighted average of students' socio-economic background weighed by students' individual weights in the school attended by individual *i* (which is computed excluding the student himself). The empirical approach for estimating the influence of individual background and school environment on student test scores is an extension of equation [1]:

$$Y_{isc} = \alpha_{1c} + \beta_{wc} \cdot F_{isc} + \beta_{bc} \cdot \overline{F}_{sc} + \varepsilon_{isc}. \quad [2]$$

Hence, while parameter β_{wc} refers to the individual's background effect, the parameter β_{bc} refers to the school environment effect. As in equation [1], equation [2] can also be extended to control for student and school-level characteristics.

The individual background effect measures the relationship between student socio-economic background and student performance within a given school, while the school environment effect measures the relationship between the average socio-economic status of families of students in a given school and individual student performance, controlling for his/her parental background (Box 5).[11] The school environment effect can be considered as a proxy for the contextual effect arising in the school, reflecting the extent to which student achievement depends on the socio-economic composition of their peer group (see Causa and Chapuis, 2009, for a detailed discussion). Not all of the contextual effect is attributable to peer-group effects; it may also reflect educational school resources and the way students are allocated within a district or region or to classes and programmes within schools (OECD, 2007a).

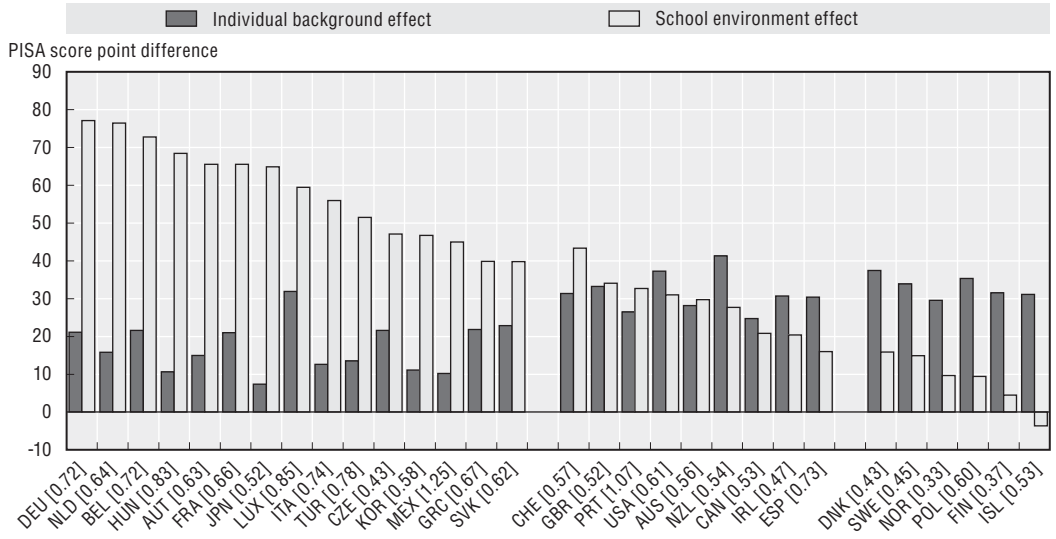
The numbers presented in Figure 7 represent, respectively: *i*) the increase in a student's PISA score obtained from moving the student from a school where the average socio-economic intake is relatively low to one where the average is relatively high; and *ii*) the increase in a student's PISA score obtained from moving the student from a relatively low socio-economic status family to one that has a relatively high socio-economic status, while he/she stays in the same school. Comparisons incorporate the impact of the country-specific distribution of socio-economic status (both within and across schools) in the analysis.[12]

In all OECD countries, there is a clear advantage in attending a school whose students are, on average, from more advantaged socio-economic backgrounds, as indicated by the school environmental effect. In over half of the OECD countries, the school environmental effect is substantially higher than that of the individual background. However, cross-country differences are striking. Some countries show substantial inequalities associated with attending different schools: this is, for instance, the case in Germany or the Netherlands, where moving a student from a below-average school environment to an above-average one raises test scores by, respectively, 77 and 76 points, while the same move in Finland and Norway raises test scores by 4 and 10 points, respectively. These cross-country patterns are in line with existing evidence, in particular when comparing comprehensive school systems (*e.g.* Nordic countries) and non-comprehensive systems (*e.g.* Austria and Germany) (OECD, 2007a; Fuchs and Wossmann, 2004; Entorf and Lauk, 2006).[13]

Figure 7. **Effects of individual background and school socio-economic environment on students' secondary achievement**[1]

Socio-economic gradient taking cross-country distributional differences into account

Differences in performance on the PISA science scale associated with the difference between the highest and the lowest quartiles of the country-specific distribution of the PISA index of economic, social and cultural status



Notes: The individual background effect is defined as the difference in performance on the PISA science scale associated with the difference between the highest and the lowest quartiles of the average individual background effects distribution of the PISA index of economic, social and cultural status, calculated at the student-level. The school environment effect is defined as the difference in performance on the PISA science scale associated with the difference between the highest and the lowest quartiles of the country-specific school-level average distribution of the PISA index of economic, social and cultural status, calculated at the student-level.

Data in brackets are values of the difference between the highest and the lowest quartiles of the country-specific school-level average distribution of the PISA index of economic, social and cultural status, calculated at the student-level.

The negative school environment effect for Iceland is not statistically significant.

1. Regression of students' science performance on students' family socio-economic background (as measured by PISA ESCS), and school-level socio-economic background (average PISA ESCS across students in the same school, excluding the individual student for whom the regression is run). Country-by-country least-squares regressions weighted by students' sampling probability. Robust standard errors adjusted for clustering at the school level. Regressions for Italy include regional fixed effects.

Source: OECD calculations based on the 2006 *OECD PISA Database*.

3.2.3. Intergenerational persistence in post-secondary education achievement

Parental background can also influence post-secondary educational achievement of their offspring, although cross-country comparable evidence is rather sparse (Box 6). Here, this issue has been investigated empirically by estimating the percentage increase (decrease) in the probability of achieving a certain level of education given parents' education based on comparable data for European OECD countries (Box 4 and Causa *et al.*, 2009, for details). This gives an indication of the extent to which the offspring's education level reflects that of their parents, and can be taken as a measure of intergenerational persistence in education.

Across all European OECD countries covered by the analysis, there is a positive estimated probability premium of achieving tertiary education associated with coming from a higher-educated family, while there is a probability penalty associated with growing up in a less-educated family (Figure 9). For pairs of fathers and sons, the estimated premium is particularly large in Luxembourg and Italy, and also in Finland and Denmark, where the probability of achieving tertiary education is almost 30 percentage points higher

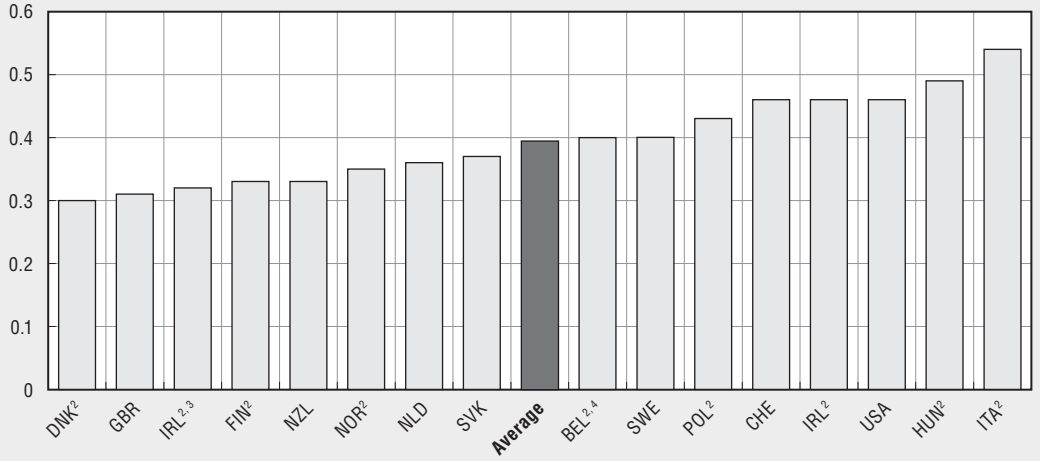
Box 6. **Post-secondary education mobility in selected OECD countries**

For the adult population, the internationally comparable evidence of educational persistence across generations is sparser than that of income persistence and the evidence of educational persistence for teenagers. Intergenerational educational persistence can be estimated either based on the number of years of formal education, or on qualification or literacy levels achieved.

Using data for a large number of countries, Chevalier *et al.* (2007) measure educational persistence based on adult literacy levels according to the International Adult Literacy Survey (IALS). They find persistence in education over generations across a wide set of developing and developed countries. The ranking of countries varies depending on the mobility measure employed. Overall, persistence is found to be high in Germany, Poland, Switzerland and the United Kingdom and lower in the Nordic countries, Belgium and the United States.* Furthermore, the intergenerational link in education is estimated to be marginally weaker for women than for men. In general, educational mobility is estimated to have increased over time.

A recent empirical study by Hertz *et al.* (2007) estimates educational mobility across generations using years of schooling for a number of countries. Again, there is persistence in education across generations for all countries (Figure 8). The correlation between parents' and their offspring's years of schooling is particularly high in Italy, Slovenia, Hungary, the United States, Switzerland and Ireland, while it is much lower in most Nordic countries (except Sweden) and the Netherlands. On average, the correlation between years of schooling for parents and their offspring is 0.39 for the countries surveyed, ranging from 0.54 in Italy to 0.30 in Denmark.

Figure 8. **Intergenerational persistence in years of schooling**[1]

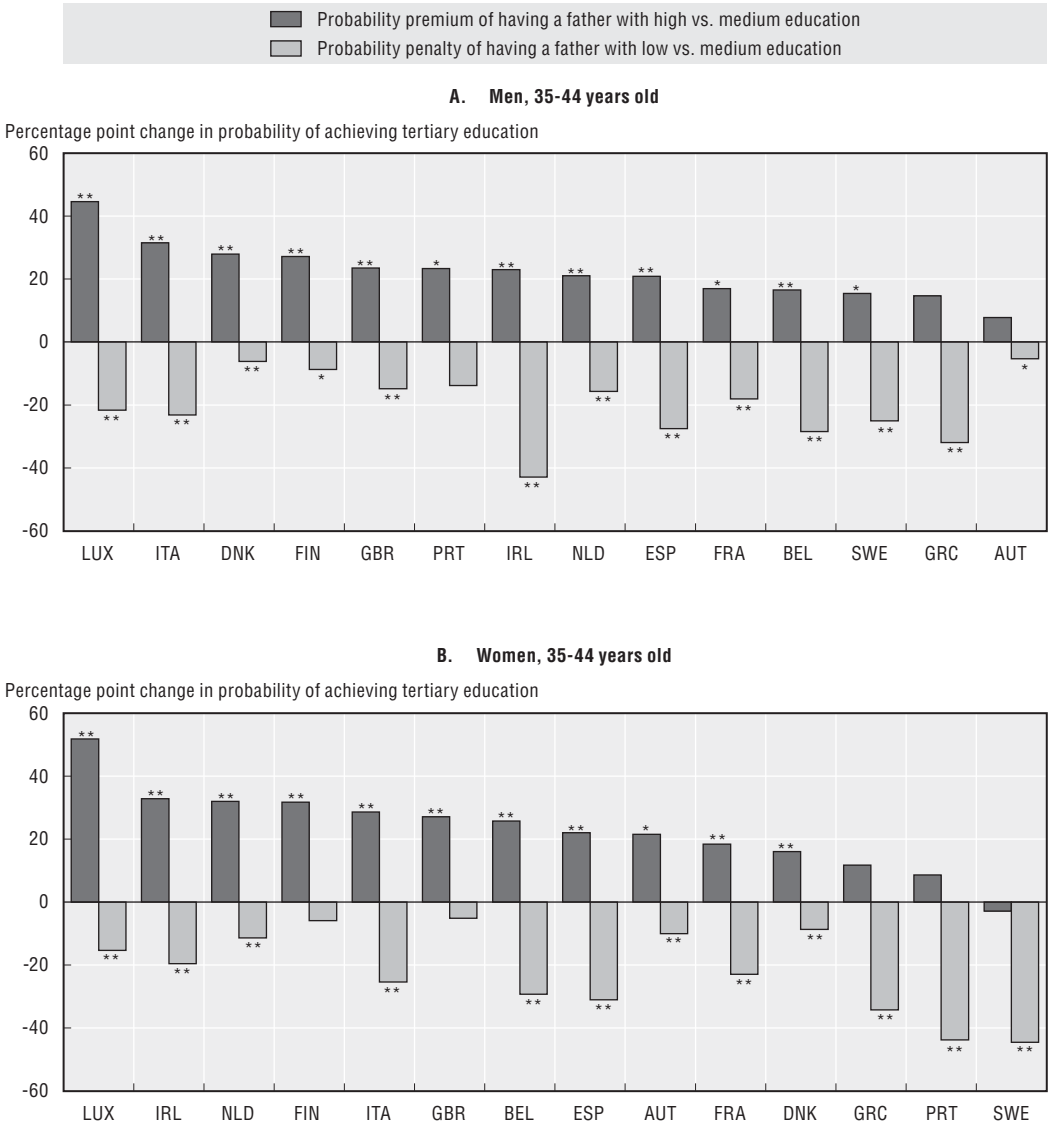


1. Correlation between parents and children's years of schooling. The correlation is the intergenerational education elasticity adjusted for the ratio of the standard deviations in years of schooling of parents and children. Data refers to men and women, aged 20-69.
2. Ages 20 to 64 or 65 only; nine cohorts.
3. Northern Ireland.
4. Belgium (Flanders).

Source: Hertz *et al.* (2007).

* This ranking is based on the eigen value mobility measure reported in Hertz *et al.* (2007).

Figure 9. **Probability premium and penalty of achieving tertiary education due to father's education levels:[1] Selected European OECD countries**



Notes: * denotes statistically significant at 10% at least.
** denotes statistically significant at 5% at least.
Based on ordered probit estimation of individuals' educational attainment, conditional on urbanisation of the living area, migration status, marital status, number of siblings and family status when the individual was a teenager. Marginal fixed effects reported.
Germany is not included in this figure, as there is a problem with the representativeness of the German sample along the education dimension.

1. The figure shows the estimated percentage point change in the probability of an offspring to achieve tertiary education depending on the offspring's parental background. The probability premium is the increase in the probability of an offspring to achieve tertiary education given that his/her father had achieved tertiary education relative to an offspring whose father had upper-secondary education. The probability penalty is the decrease in the probability of an offspring to achieve tertiary education given that his/her father had achieved below upper-secondary education relative to an offspring whose father had upper-secondary education.

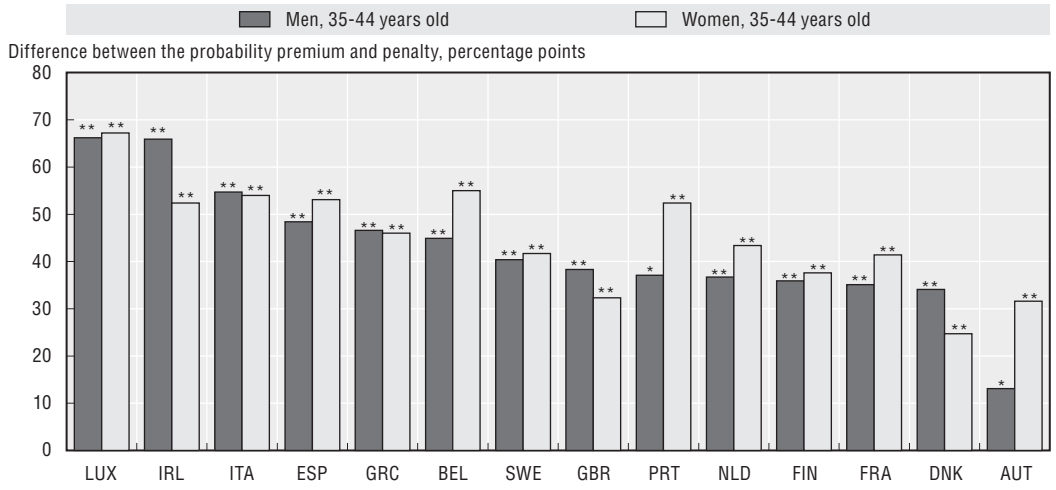
Source: OECD calculations based on the 2005 *EU-SILC Database*.

for a son whose father had tertiary education, compared with a son whose father had only upper-secondary education. The estimated penalty of coming from a low-educated family is sizeable in Ireland and Greece.[14] The ranking of the probability premium for pairs of fathers and daughters is relatively similar to that of sons. However, there are some differences. Daughters' probability premium is significantly lower than that of sons in Denmark, while it is much higher in the Netherlands, Ireland, Belgium and Austria. The probability penalty for daughters associated with growing up in a low-educated family is higher than that for men in several countries, particular in Portugal and Sweden.

3.2.4. Summary measure of persistence in tertiary education

In the same way as with intergenerational wage persistence, the persistence in tertiary education can be summarised by measuring the gap between the probability premium and penalty to achieve tertiary education, as reported above. A larger gap implies that a father's education more strongly influences individuals' education and, therefore, indicates stronger persistence in tertiary education across generations. According to this measure, persistence is relatively high in Luxembourg, Ireland and in most southern European countries, while it is relatively low in Austria and Denmark (Figure 10), in line with previous comparative studies (*e.g.* Hertz *et al.*, 2007, and Box 6).

Figure 10. **Summary measure of persistence in tertiary education:**[1] **Selected European OECD countries**



Notes: * denotes statistically significant at 10% at least.
** denotes statistically significant at 5% at least.
Germany is not included in this figure, as there is a problem with the representativeness of the German sample along the education dimension.

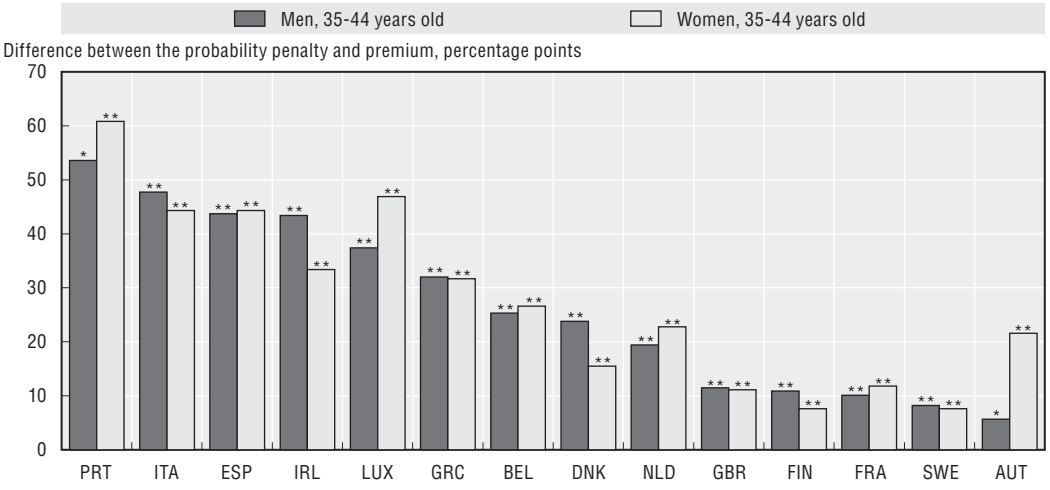
1. Persistence in tertiary education is measured as the distance between the estimated probability premium and penalty. Thus, it measures the percentage point increase in the probability of an offspring having a father with tertiary education to achieve tertiary education relative to an offspring having a father with below-upper secondary education. A larger number implies a larger gap, thus stronger persistence in tertiary education or a higher degree of educational immobility across generations. Based on ordered probit estimation of individuals' educational attainment. Marginal fixed effects reported.

Source: OECD calculations based on the 2005 *EU-SILC Database*.

3.2.5. *Intergenerational persistence in below upper-secondary education achievement*

In all European OECD countries covered by the analysis, there is an estimated increase in the probability of achieving below upper-secondary education ("a probability penalty") for a son or daughter whose father had achieved below upper-secondary education compared with one whose father had achieved upper-secondary education (see Causa *et al.*, 2009, for details). This probability penalty amounts on average to 18 percentage points. Likewise, in most countries there is an estimated decrease in the probability ("a probability premium"), on average 10 percentage points, for an offspring to achieve below upper-secondary education if their father had achieved tertiary education compared with one whose father had achieved upper-secondary education. Persistence in below-upper secondary education is summarised by the difference in the probability of achieving below-upper secondary education, depending on paternal education attainment, where a larger difference implies stronger persistence (Figure 11). According to this metric, persistence in below-upper secondary education is relatively strong in certain southern European countries, Ireland and Luxembourg, while it is lower in Austria, some Nordic countries, France and the United Kingdom.

Figure 11. **Summary measure of persistence in below-upper secondary education:**[1] **Selected European OECD countries**



Notes: * denotes statistically significant at 10% at least.
** denotes statistically significant at 5% at least.
Germany is not included in this figure as there is a problem with the representativeness of the German sample along the education dimension.

1. Persistence in below upper-secondary education is measured as the distance between the estimated probability penalty and premium. Thus, it measures the percentage increase in the probability of an offspring having a father with below upper-secondary education to achieve below upper-secondary education relative to an offspring having a father with tertiary education. A larger number implies a larger gap, thus stronger persistence in below upper-secondary education or a higher degree of immobility across generations. Based on ordered probit estimation of individuals' educational attainment. Marginal fixed effects reported.

Source: OECD calculations based on the 2005 *EU-SILC Database*.

3.3. *Intergenerational social mobility in OECD countries: some concluding remarks*

In this study, intergenerational social mobility is measured by several different indicators, since no single indicator provides a complete picture of social mobility. One pattern that emerges is a group of countries that appears relatively immobile on most indicators (*e.g.* southern European countries and Luxembourg) and another group that tends to be relatively mobile (*e.g.* Nordic countries). However, these indicators do not necessarily provide the same picture of persistence across countries. For instance, the United Kingdom seems to be less mobile in terms of wage persistence (measured by the summary indicator of wage persistence) than in terms of education persistence (measured by the summary indicators of tertiary and below upper-secondary education persistence), while the reverse is the case in Ireland. In some other cases there appears to be a relatively large premium in achieving tertiary education associated with growing up in a well-educated family at the same time as the penalty of growing up in a less-advantaged family is fairly low (*e.g.* Denmark and Finland), whilst the reverse is true in some other countries (*e.g.* Sweden and Greece). Differences in cross-country rankings of persistence also emerge when comparing the measure of secondary education persistence (*i.e.* the influence of socio-economic background on students' PISA score) with education persistence measures. For example, in France persistence appears to be much stronger on the former than on the latter measures.[15]

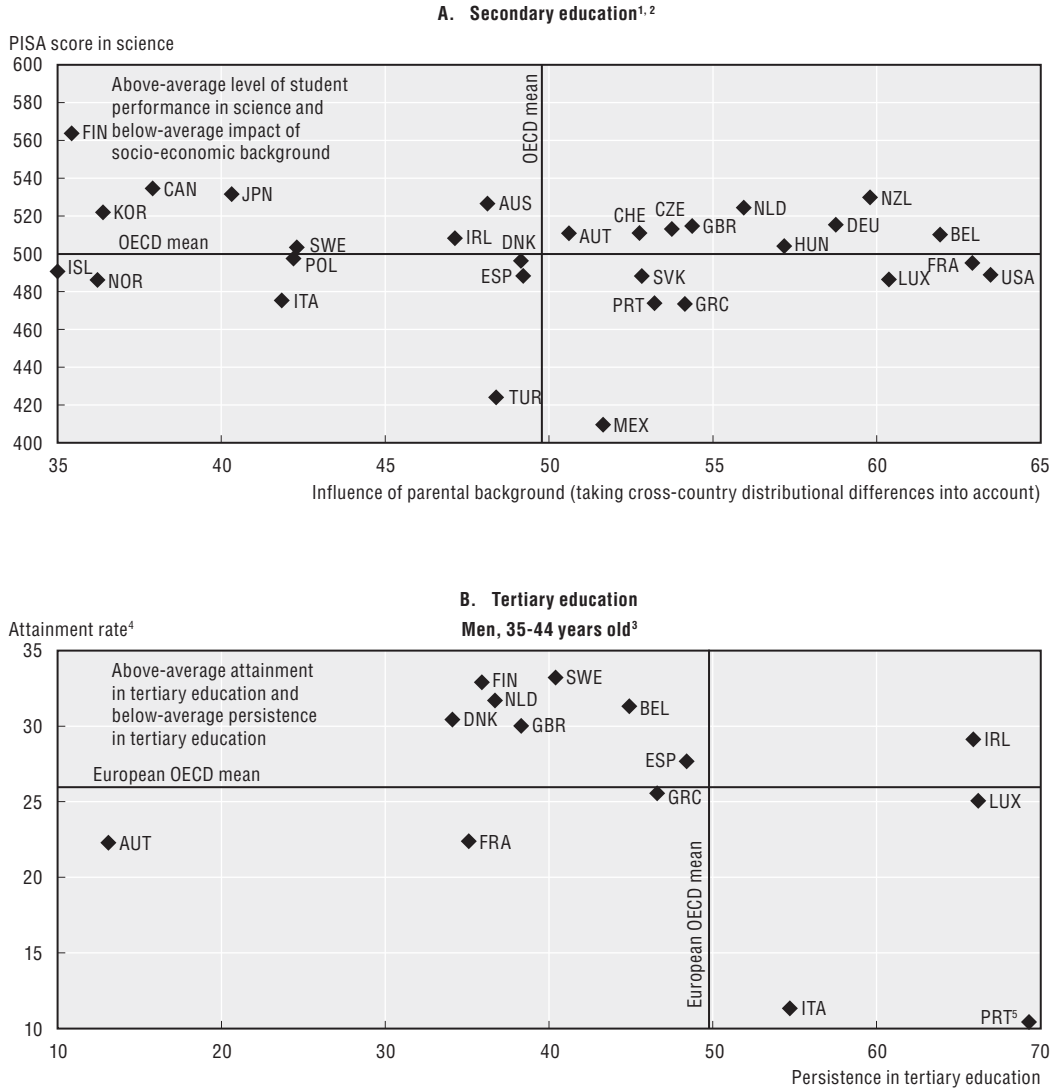
3.3.1. *Performance and equity in education*

Even though family background influences offspring secondary and post-secondary educational achievement in all OECD countries, albeit to a varying degree, some countries have relatively low persistence in education *and* relatively high average schooling performance (OECD, 2007a). In Finland, Canada, Korea and Japan, students attending secondary education perform above OECD average on PISA scores, while the influence of socio-economic background is below OECD average (Figure 12, panel A). Likewise, in Finland, Sweden and Denmark, persistence in tertiary education over generations is relatively low, whereas attainment levels are fairly high (Figure 12, panel B). This may reflect cross-country differences in public policies, suggesting policies partly offset the effect of family background on educational outcomes.

3.3.2. *Low mobility in education could translate into inequalities in wages*

Obstacles to social mobility may accumulate, making the achievement of upward wage mobility particularly hard for the offspring of disadvantaged families. Inequalities at one stage of life translate into inequalities at later stages. Since learning is an ongoing process and skills acquired at one stage raise productivity and cognitive development in the next stage (*e.g.* Cuhna *et al.,* 2006), inequalities that arise in secondary education are likely to translate into inequalities in higher education. For instance, a recent OECD study showed that in Canada top performing students according to PISA scores were much more likely to attend university than their lower performing peers (OECD, 2010). In turn, such advantages could translate into inequalities in wages via returns to education in the labour market, or possibly through employability.

Figure 12. **Performance and equity in education**



1. Regression of students' science performance on students' PISA index of economic, social and cultural status (ESCS). Country-by-country least-squares regressions weighted by students' sampling probability. Robust standard errors adjusted for clustering at the school level.
2. Socio-economic gradient, taking cross-country distributional differences into account: effect of students' socio-economic background on student performance in science, defined as the difference in performance on the PISA science scale associated with the difference between the 75th and the 25th quartiles of the country-specific distribution of the student PISA index of economic, social and cultural status.
3. Persistence in tertiary education is measured as the distance between the estimated probability premium and penalty in achieving tertiary education. It measures the percentage point increase in achieving tertiary education of a child whose father had achieved tertiary education relative to a child whose father had below upper-secondary education. A larger number imply a larger gap, thus stronger persistence in education.
4. The attainment rate is defined as the percentage of 35-45 year old men in the population that has attained tertiary education according to *OECD Education at a Glance Database*.
5. 25-34 years old for persistence in tertiary education in Portugal.

Sources: OECD calculations based on the 2006 *OECD PISA Database* and on the 2005 *EU-SILC Database*, *OECD Education at a Glance Database*.

4. Inequality, intergenerational social mobility and growth: the role of policies

4.1. *Mobility and growth*

Intergenerational social mobility may have positive effects on economic growth through the allocation of talents and abilities in the economy. Lacking such mobility, potential misallocation of talents and skills may lead to inefficiencies, with negative consequences for growth (*e.g.* Galor and Tsiddon, 1997; Murphy *et al.*, 1991, and Box 7). Thus, public policies aimed at removing obstacles to intergenerational social mobility may improve the allocation of resources, thereby increasing growth. The reverse is also possible,

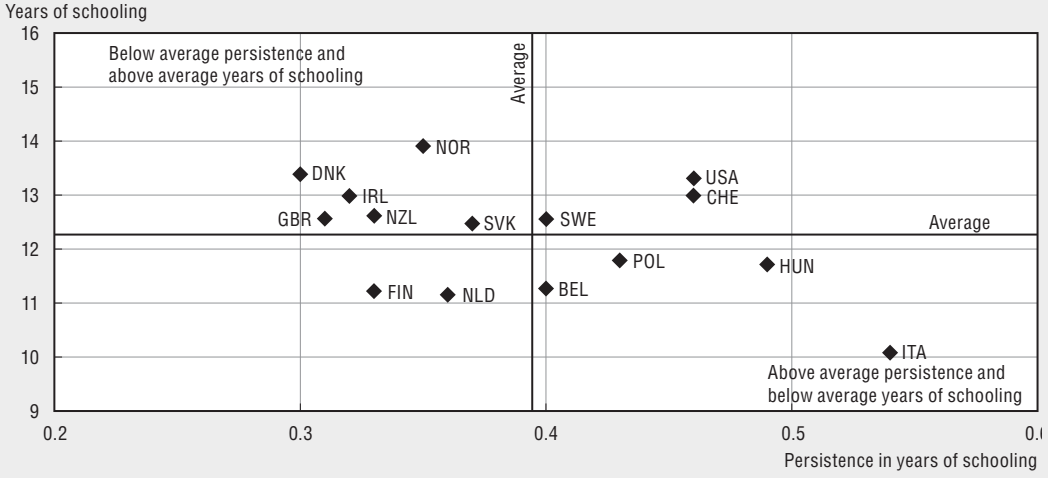
Box 7. **The potential effect of social mobility on growth**

A simple numerical example can illustrate the potential impact of increasing social mobility on growth. Given the simplifying assumptions underlying the calculation, this example should be seen as purely speculative. Consider intergenerational education persistence and assume that the average relation between parent and offspring years of schooling in OECD countries (expressed in differences from average years of schooling among OECD countries) is:

Offspring years of schooling = γ^* Parent years of schooling.

The average years of schooling are 12.2 years and the average relationship between offspring and parent years of schooling, γ, is 0.39 (Hertz *et al.*, 2007). Now, consider a country in which years of schooling fall short of the OECD average, at the same time as persistence in years of schooling is above OECD average (Figure 13). For example, consider Italy with average years of schooling of 10.1 years and average persistence in years of schooling of 0.54. In this country, 1.16 years [*i.e.* 0.54*(10.1 – 12.2)] of the shortfall could potentially be passed on to offspring from parents. Reducing persistence in schooling to the OECD average of 0.39 would reduce this shortfall that could be passed on to the next generation to 0.85 [0.39*(10.1 – 12.2)]. Thus, reducing intergenerational persistence in schooling to the OECD average would reduce from 1.16 to 0.85 the shortfall in years of schooling (relative to the OECD average) that could potentially be passed on from one generation to another.

Figure 13. **Intergenerational persistence and average number of years of schooling**[1]



1. Persistence refers to the correlation between parents and children's years of schooling. The correlation is the intergenerational education elasticity adjusted for the ratio of the standard deviations in years of schooling of parents and children. Data refers to men and women, aged 20-69.

Sources: Hertz *et al.* (2001) and *Education at a Glance*, 2006.

Box 7. **The potential effect of social mobility on growth** *(cont.)*

The effect on long-run GDP per capita of a decrease in educational persistence, resulting in an increase in average years of schooling, depends on the influence of additional years of schooling on GDP as well as on how much of the original shortfall in schooling is explained by the offsprings being constrained by their background. Recent OECD estimates suggest that one additional year of schooling would increase the long-run level of GDP per capita by between 4 to 7% (OECD, 2003). To the extent that the short-fall is entirely due to the fact that in Italy the offspring are constrained by their background, the potential increase in years of schooling from reducing persistence would translate into a 1.3 to 2.2% (*i.e.* 0.31*4 and 0.31*7) increase in long-run GDP per capita (see Table 1 below). However, if the shortfall is only partly explained by parental background, then the range of GDP per capita gains from decreasing persistence would be smaller. The numbers obtained in this example need to be interpreted with caution as a number of caveats apply to this exercise. It is likely that the misallocation of human resources is not fully captured by the link between parents and their offspring education. Further, persistence in education may not be measured properly by the relation between parents and offspring years of schooling.

Table 1. **The effect of increased mobility on long-run growth**

Per cent

	Short-fall in schooling explained fully by background	Short-fall in schooling explained half by background	Short-fall in schooling explained one-fifth by background
High influence of education on long-run GDP (7%)	2.2	1.1	0.4
Moderate influence of education on long-run GDP (5.5%)	1.7	0.9	0.3
Low influence of education on long-run GDP (4%)	1.3	0.6	0.2

Source: OECD calculations.

with faster economic growth generating more opportunities and enhancing intergenerational social mobility if these opportunities disproportionately benefit the disadvantaged. For instance, in periods of major technological progress, the relative importance of individual ability relative to parental background to understand and take advantage of available economic opportunities may increase. This enhances mobility and generates a higher concentration of high-ability, better-educated individuals in technologically advanced sectors, which in turn stimulates growth (Galor and Tsiddon, 1997).[16]

4.2. Mobility and inequality

An important channel through which public policies could influence intergenerational social mobility is by affecting intra-generational inequality. The distribution of cross-sectional household income is strongly influenced by the distribution of wages (*e.g.* Galbraith and Kum, 2005; Gottshalk and Danziger, 2005), which in turn reflects differences in returns to education. Differences in wage distribution across countries also reflect labour supply and demand factors, as well as the institutional environment (*e.g.* Blau and Kahn, 1996, 2003; Acemoglu, 2003; OECD, 2002). Across OECD countries, wage dispersion is lower in countries where institutions compress the distribution of wages (*e.g.* the Nordic countries). However, recent OECD evidence shows that such institutions

also tend to reduce employment among older workers (*e.g.* Bassanini and Duval, 2006) and thus reduce the overall share of wage-earners in the economy. In turn, this increases cross-sectional income inequality across the entire population.[17]

However, the relationship between cross-country income and/or wage inequality and intergenerational income persistence is not straightforward, as various factors are at work, sometimes in opposite directions. On the one hand, countries with a wide distribution of income are also likely to be those where the returns to education are relatively high. As discussed above, if parental background or income affects access to and/or investment in education through credit or other constraints, then the ability to take advantage of the high returns from education is limited to the offspring of relatively advantaged parents (Corak, 2006; Solon, 2004, d'Addio, 2007). Therefore, when inequalities between parents increase, intergenerational mobility falls because it is easier for advantaged parents to buy their children educational advantages that disadvantaged parents cannot afford (Burtless and Jencks, 2003).[18] On the other hand, inequality could increase intergenerational mobility by enhancing incentives to undertake effort (*e.g.* Lazear and Rosen, 1981) by working longer hours or by strengthening incentives to undertake education, which could result in more investment in education if financial markets are sufficiently developed.[19] With returns to education likely to be higher in more unequal societies, and with incentives to acquire additional education stronger in countries where the "pay-off" from doing so is relatively larger, social mobility could be higher in countries where income or wage dispersion is higher.

4.2.1. Positive association between intergenerational income persistence and inequality

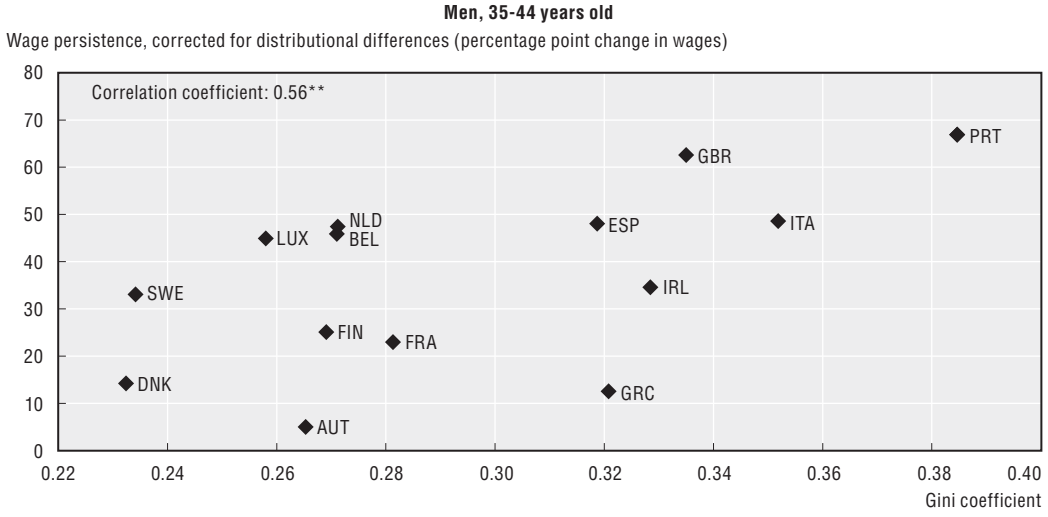
While theory and evidence are mixed, some studies suggest that higher cross-sectional inequality tends to be associated with lower mobility (Björklund and Jäntti, 1997; Solon, 2004; Andrews and Leigh, 2009; Corak, 2006; d'Addio, 2007). Indeed, the association between cross-sectional inequality (measured by the Gini coefficient of household disposable income) and the persistence in wages across generations measured by the estimated wage gap between individuals coming from different family backgrounds is positive in European OECD countries covered by the analysis (Figure 14). OECD estimates also show that a higher degree of inequality is associated with a greater influence of individual socio-economic background on student cognitive achievement in secondary education in a larger set of OECD countries (Causa and Chapuis, 2009).

Similarly, there is a positive association across European OECD countries between intergenerational persistence in wages and poverty rates (based on a measure of household disposable income), although weaker than the association between persistence and inequality (see Causa *et al.*, 2009). Again, this link is recorded for OECD countries at the level of teenagers' cognitive skills. More specifically, higher levels of child poverty (measured after taxes and transfers) and a greater lack of basic resources are associated with a stronger influence of parents' socio-economic background on their offspring's cognitive achievement.

4.3. Mobility and policies

Insofar as faster economic growth enhances social mobility, policies that have a positive effect on the drivers of growth (*e.g.* tax or labour-market reforms) could also increase social mobility across generations. Moreover, the direct effect of these policies on growth is likely to materialise quicker than any indirect effect through social mobility, since mobility largely influences growth by improving the allocation of human resources

Figure 14. **Correlation between inequality and intergenerational wage persistence (corrected for distributional differences):[1] Selected European OECD countries**



Notes: ** denotes significant at 5%.

Germany is not included in this figure, as there is a problem with the representativeness of the German sample along the education dimension.

1. Persistence in wages is measured as the distance between the estimated wage premium and penalty. Thus, it measures the percentage increase in wages of an offspring having a father with tertiary education relative to an offspring having a father with below upper-secondary education. A larger number implies a larger gap, thus stronger persistence in wages or a higher degree of immobility across generations. The wage premium (penalty), corrected for distributional differences, corresponds to the wage premium (penalty), multiplied by the ratio of the standard deviation of fathers' education to the standard deviation of sons' or daughters' gross hourly wage. Inequality is measured by the Gini coefficient of disposable household income adjusted for household size.

Sources: OECD calculations based on the 2005 *EU-SILC Database* and OECD 2008, *Growing unequal?*

over generations, which takes a long time to materialise. Thus, it is likely that any direct effect of a policy on drivers of growth outweighs the indirect effect via social mobility, at least in the short to medium term.

At the same time, some of the policies that are thought to positively affect social mobility by reducing inequality may also have adverse effects on drivers of growth (*i.e.* labour utilisation or productivity). Conversely, some policies that are thought to enhance the drivers of growth may have adverse effects on social mobility. In this situation, a prudent approach could be to implement policies that remove obstacles to intergenerational social mobility without any adverse side effects on economic growth. Furthermore, it may be desirable to accompany growth-oriented policies with measures to lower their potentially negative effect on social mobility (especially through inequality), both because it may be desirable in itself and because it may reduce potentially harmful side effects on growth.

Ultimately, both the effects on growth of policies encouraging social mobility and those on mobility of policies encouraging growth are an empirical issue. While assessing the former effects is beyond the scope of this study, the remainder of this section explores the role played by a range of public policies *vis-à-vis* social mobility, especially regarding inequality. The empirical strategy for analysing such role of policies in a cross-country context is described in Box 8 (with more details to be found in Causa and Chapuis, 2009, and Causa *et al.*, 2009).

Box 8. **The influence of policies on intergenerational social mobility**

This box provides a simplified and stylised description of the common empirical approach underlying the cross-country analyses of the role of policies for intergenerational social mobility, based on PISA data for teenagers' cognitive skills and EU-SILC data for wages. The approach is based on two cross-country variants of the country-level analyses described in Boxes 3 and 4 (for details see Causa and Chapuis, 2009 and Causa *et al.*, 2009):

$$O_{ic} = \alpha_1 + \lambda \cdot F_{ic} + \gamma_c \cdot X_{ic} + \delta \cdot P_c \cdot F_{ic} + \phi \cdot P_{c\cdot} + \psi \cdot Z_{c\cdot} + \varepsilon_{ic}, \quad [1a]$$

$$O_{ic} = \alpha_1 + \lambda \cdot F_{ic} + \gamma_c \cdot X_{ic} + \delta \cdot P_c \cdot F_{ic} + \theta \cdot C_{c\cdot} + \varepsilon_{ic}, \quad [1b]$$

where O_{ic} denotes outcomes (gross hourly wages and test score in PISA) of individual i in country c, F_{ic} denotes parental/family background (father's education or family socio-economic status), X_{ic} denotes individual characteristics, Z_c denotes country-level variable(s), P_c denotes country-level policy variables and C_c denotes country fixed effects. In these equations, individual characteristics display country-specific coefficients. Equations [1a] and [1b] describe country-specific models, in which only the impact of the variables F_{ic} is restricted to be equal across countries.

Equation [1a] allows estimating the direct impact of policies on individual's outcome, while equation [1b] includes country-fixed effects and thus cannot identify the direct influence of a policy on the dependent variable as policies do not vary within a country or across cohorts. In order to assess the impact of policies on persistence, the analysis focuses on the signs and the magnitude of the interaction coefficient δ. Indeed, the family background effect varies across policy settings as follows:

$$\frac{\partial O_{ic}}{\partial F_{ic}} = \hat{\lambda} + \hat{\delta} \cdot P_c, \quad [1c]$$

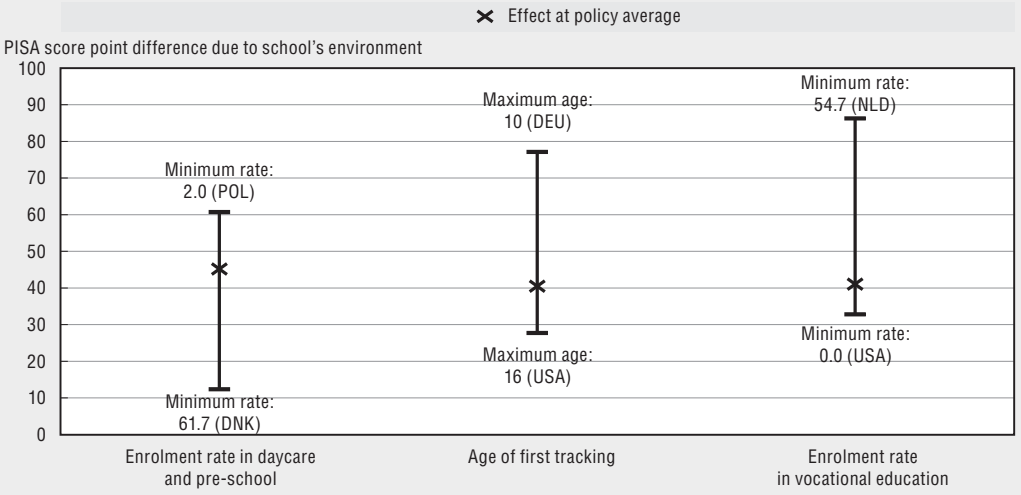
where hats indicate estimated coefficients. A positive δ means that the influence of family background on outcomes increases ($\lambda + \delta > \lambda$) and a negative δ means that it decreases ($\lambda + \delta < \lambda$) with the policy indicator P_c.

Equation [1c] can also be used to calculate the family background effect associated with different levels of the policy indicator across OECD countries (*e.g.* minimum, mean or maximum), providing a tentative way to quantify the relative impact of policies on equality of opportunity.

Following this approach, Figures 15, Figure 16 and 17 provide illustrative examples of the quantitative impact of policies on persistence in secondary education and wages, by simulating family background effects under different policy settings corresponding to the observed variation of policies across the countries covered by estimations. Figure 15 shows that increasing enrolment in childcare from the lowest level in the OECD (2%) to the highest (62%) would bring down the influence of the school environment effect on student performance from 61 to 13 test points in the PISA score. Similarly, Figure 17 shows that raising the average unemployment benefits from the lowest to the highest level in the OECD would reduce the wage gap associated with different family backgrounds from 15 to 0.7 percentage points.

Box 8. **The influence of policies on intergenerational social mobility** *(cont.)*

Figure 15. **Effect of the school socio-economic environment on secondary education achievement under different policy settings:**[1, 2] **OECD countries**



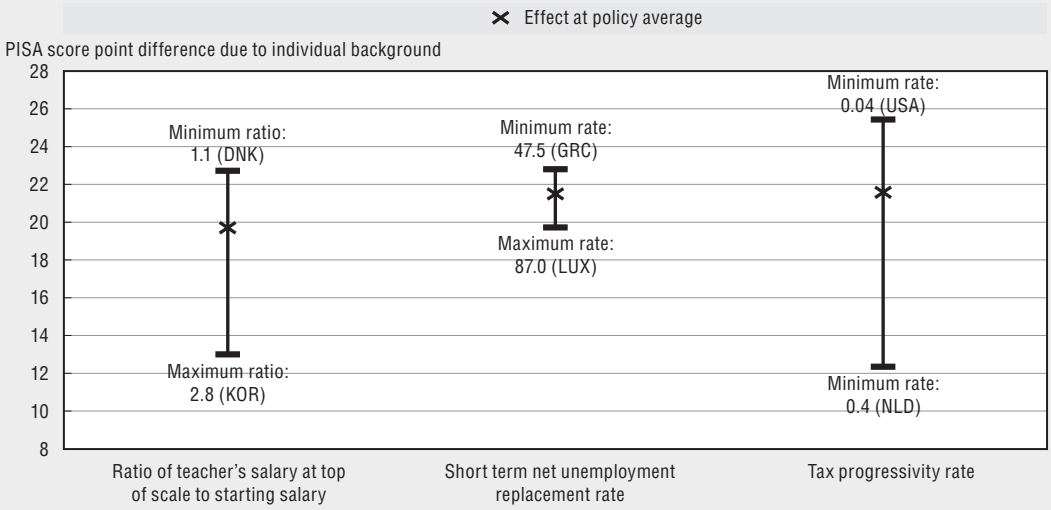
Note: Based on cross-country regressions presented in OECD Economics Department *Working Paper* No. 708, "Equity in Student Achievement across OECD Countries: An Investigation of the Role of Policies" by Orsetta Causa and Catherine Chapuis.

1. Each bar represents the change in the school environment effect associated with a change from the least to the most mobility-friendly level of the policy (based on OECD countries' policies distribution, excluding Mexico and Turkey).
2. Regression of students' science performance on student socio-economic background, individual control variables (gender, migration status and language spoken at home), school-level socio-economic background (average across students in the same school, excluding the individual student for whom the regression is run), school location (small town or village, city), school size and school size squared, school resources (index of quality of educational resources, index of teacher shortage, proportion of certified teachers, ratio of computers for instruction to school size), average class size, average student learning time at school and school type (private independent, private government dependent, public). Student ESCS and school-level ESCS are interacted with policy variables, entered one at a time. The regression includes country fixed effects. Country-specific parameters are used for all variables except student socio-economic background, school socio-economic background, and policy interactions. Cross-country least-squares regressions weighted by students' sampling probability, rescaled so that each country receives an equal weight, while taking country–specific sample representativeness into account.

Sources: OECD calculations based on *PISA 2006 Database*, various OECD and non-OECD sources.

Box 8. **The influence of policies on intergenerational social mobility** *(cont.)*

Figure 16. **Effect of individual parental background on secondary education achievement under different policy settings:**[1, 2] **OECD countries**



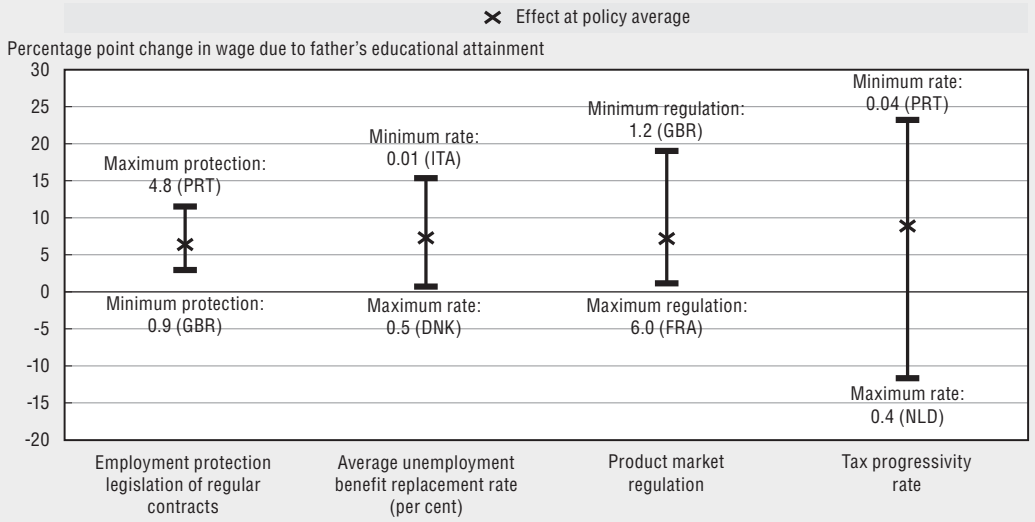
Note: Based on cross-country regressions presented in OECD Economics Department *Working Paper* No. 708 "Equity in Student Achievement across OECD Countries: An Investigation of the Role of Policies" by Orsetta Causa and Catherine Chapuis.

1. Each bar represents the change in the individual background effect associated with a change from the least to the most mobility-friendly level of the policy (based on OECD countries' policies distribution, excluding Mexico and Turkey).
2. Regression of students' science performance on student socio-economic background, individual control variables (gender, migration status and language spoken at home), school-level socio-economic background (average across students in the same school, excluding the individual student for whom the regression is run), school location (small town or village, city), school size and school size squared, school resources (index of quality of educational resources, index of teacher shortage, proportion of certified teachers, ratio of computers for instruction to school size), average class size, average student learning time at school and school type (private independent, private government dependent, public). The regression includes country fixed effects. Student socio-economic background (and school socio-economic background in the case of the Ratio of teachers's salary at top of scale to starting salary) are interacted with policy variables, entered one at a time. Country-specific parameters are used for all variables except student socio-economic background, school socio-economic background (in the case of the ratio of teachers's salary at top of scale to starting salary) and policy interactions.Cross-country least-squares regressions weighted by students' sampling probability, rescaled so that each country receives an equal weight, while taking country–specific sample representativeness into account.

Sources: OECD calculations based on *PISA 2006 Database*, various OECD and non-OECD sources.

Box 8. **The influence of policies on intergenerational social mobility** *(cont.)*

Figure 17. **Effect of father's educational attainment on his son's wage under different policy settings:[1, 2] Selected European OECD countries**



Note: Based on cross-country regressions presented in OECD Economics Department *Working Paper* No. 709 "Intergenerational Social Mobility in European OECD Countries" by Orsetta Causa, Sophie Dantan and Åsa Johansson.

1. Each bar represents the change in the parental background effect (father's level of education) associated with a change from the least to the most mobility-friendly level of the policy (based on the European OECD countries' policies distribution).
2. Regression of men's hourly wages on father's level of education, own level of education, individual control variables (urbanisation of the area of residence, marital status, and migration background). The regression includes country-cohort fixed effects. The fathers' level of education is interacted with policy variables, entered one at a time. Country-cohort specific parameters are used for all variables except for father's level of education and policy interactions. Cross-country least-squares regressions weighted by individual sampling probability, rescaled so that each country receives an equal weight, while taking country-specific sample representativeness into account.

Sources: OECD calculations based on the 2005 *EU-SILC Database*, various OECD and non-OECD sources.

These illustrative calculations have to be taken with great caution, given the empirical limitations associated with the underlying estimations. In particular, the finding of a significant correlation between the distribution of policies and the distribution of family background effects should not be interpreted in a causal way. Moreover, the impact of a particular policy might indeed capture the impact of another, correlated and omitted policy.*

* It is not possible to introduce several policies at the same time because multicollinearity makes it difficult to identify their respective impact.

4.4. Early intervention policies

There is a growing recognition that access to early childhood education and care could provide young children, particularly from low-income and second-language groups, with a good start in life (Carneiro and Heckman, 2003; Machin, 2006; d'Addio, 2007; OECD, 2006a, 2007c). The provision of cost-effective and quality childhood education and care is on the government's agenda in many countries. Policies such as "Sure Start" in the United Kingdom and "Head Start" in the United States are designed to level the playing field at or near school-entry age for children from disadvantaged backgrounds. Existing evidence

concerning the impact of such programmes suggests that they have been successful in alleviating some of the initial gaps of children born in adverse family environments (*e.g.* Heckman, 2005; Currie and Blau, 2005; Brooks-Gunn, 2003; Sylva *et al.*, 2004; OECD, 2004). Cross-country regression results obtained in the context of this study suggest that enrolment in early childcare and education (day-care and pre-school) as well as spending on childcare and early education, are inversely related to the influence of family background on cognitive skills of teenagers (Figure 15 in Box 8 and Causa and Chapuis, 2009).

4.5. *Educational policies and intergenerational social mobility*

4.5.1. *Education policies and school practices*

Several empirical studies have documented a negative influence of early tracking policies on equality in educational achievement.[20] Systems that start grouping students early in their educational curricula tend to be associated with larger socio-economic inequalities, with no associated gains in average performance (OECD, 2007a). Results from cross-country regressions confirm these findings, suggesting that the influence of parental background on offspring performance at secondary school tends to be lower in countries where tracking takes place at a later stage and/or where ability grouping within schools occurs to a lesser extent (so called "comprehensive" systems), as compared with countries in which tracking and ability grouping occurs earlier (so called "non-comprehensive" systems). Regression estimates suggest that moving from a system that separates students into different schools at age ten (as is done in Germany and Austria) to a system that separates students at age sixteen (as is done in half of OECD countries) would reduce the effect of the school's socio-economic environment from 77 to 27 PISA score-points (Figure 15 in Box 8).[21]

Vocational education varies substantially across OECD countries in its design and implementation, as well as in its degree of success in equipping individuals with the skills needed in the labour market (*e.g.* Machin and Vignoles, 2005; Büchel, 2002). In many OECD countries, upper-secondary students can enrol in vocational programmes, while some countries delay vocational education (*e.g.* Canada and the United States).[22] Moreover, in some countries vocational training takes place mainly in schools and colleges (*e.g.* Nordic and Eastern European countries), while in other countries such training takes place mainly in the workplace through apprenticeships (*e.g.* Germany and Austria) or through a combination of school and workplace. These differences need to be kept in mind when evoking the concern that vocational education within secondary education ends up grouping "weak/disadvantaged" students into programmes that limit their future learning possibilities in a way similar to early tracking. Cross-country estimates suggest that there is a positive association between enrolment in vocational education and the influence of parental background on offspring secondary achievement (as measured by PISA scores). Vocational education at the secondary education level appears to exacerbate achievement differences associated with the school socio-economic environment without increasing overall performance.

4.5.2. *Education policies and resources*

The link between human capital and growth has been emphasized in the policy debate, and in many countries spending on education has increased since the mid-1990s. However, research on the relationship between educational spending and student performance is less encouraging. Most reviews reach the same conclusion: some measurable school inputs do matter for performance but the magnitude of their effects is

relatively small (Hanushek, 2003, for a review; Schütz *et al.,* 2005; OECD, 2007a). Cross-country regression estimates performed in the context of this study also suggest that increasing educational resources – either through raising spending or reducing class size- might not be the most effective tool for promoting equity in secondary education (see Causa and Chapuis, 2009).[23] By contrast, the ability to prioritise and allocate resources efficiently, measured by recently constructed OECD indicators capturing the "degree of decentralisation" and "degree of mechanisms matching resources to specific needs", seems to be negatively associated with the influence of parental background on offspring achievement in secondary education (see Sutherland and Price, 2007, for details of these indicators). This effect mainly derives from a weaker association between the school socio-economic environment and individual student performance.

The importance of teacher quality is rather well established (*e.g.* Hanushek, 2005, for an overview). New estimates undertaken for this study show a negative association between the proportion of qualified teachers and the influence of parental background on offspring achievement at secondary school. While raising teacher quality/skills might promote educational equity, little is known on how to translate this into effective policy. One frequent suggestion is to raise their salary levels, increase salaries in the most disadvantaged schools or areas, or introduce performance-based pay. Indeed, cross-country estimates suggest that the influence of family background on student achievement at secondary school is lower in countries where teacher wage profiles are steeper over their career. However, it should be recognised that such wage profiles may not capture performance-based pay systems, but rather constitute a proxy for cross-country differences in "seniority wage profiles".

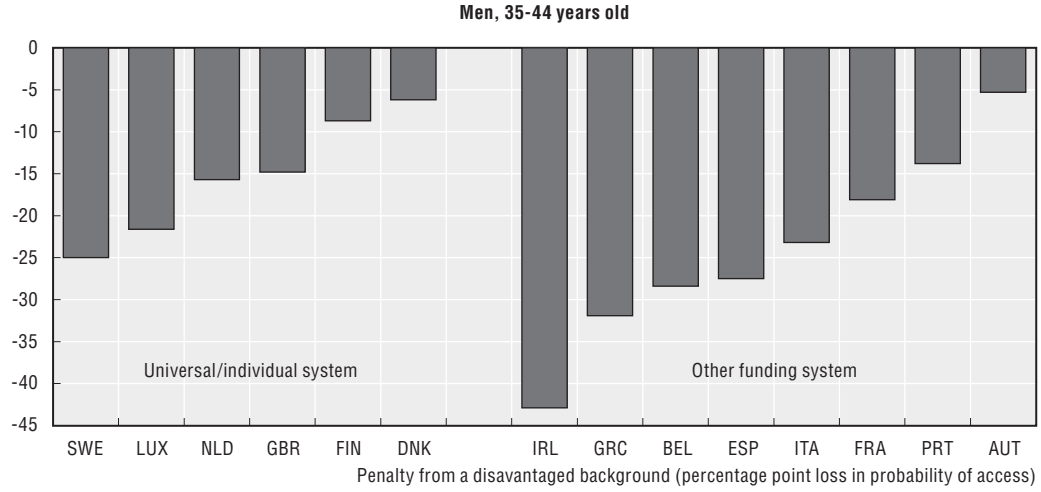
4.5.3. *Loan systems and persistence in post-secondary education*

Evidence of credit constraints in undertaking tertiary education is rather limited and mostly concerns the United States. A few studies tend to suggest that credit constraints may not be the greatest obstacle to accessing higher education for disadvantaged students (Carneiro and Heckman, 2003; Dreaden *et al.,* 2004; Freynette, 2007; Wossman, 2008); rather it is the lack of adequate qualifications to be accepted into higher education, which points to the need for policies to intervene earlier (see above). By contrast, a recent study found evidence of the presence of credit constraints in post-secondary education in some European countries (Vandenberghe, 2007) and recent OECD work also found that lower financial constraints are associated with higher tertiary graduation rates (Oliveira Martins *et al.,* 2007). If financial constraints are present they are likely to be more important for able offspring from low-income backgrounds. In fact, cross-country empirical evidence shows that in a few European OECD countries (*e.g.* Belgium, France, Italy, Luxembourg, the Netherlands and the United Kingdom), financial constraints may hold back highly able individuals from disadvantaged backgrounds (see Causa *et al.,* 2009, for details).[24]

The design of tertiary educational loan systems and student support differs across OECD countries. Some countries apply universal/individual-based systems which consider higher education students as financially independent from their parents, whereas others use systems in which students are considered members of their families for the purpose of both financing and taxation. In general, in countries using other types of funding systems than the universal/individual systems, the penalty of having a lower-educated father for achieving tertiary education is larger (Figure 18). There is suggestive evidence that universal government-supported loan systems can reduce liquidity constraints, thereby

enhancing equality of access while maintaining incentives for swift and successful study completion (Oliveira Martins *et al.*, 2007).

Figure 18. **Funding system and access to tertiary education:**[1]
Selected European OECD countries



Note: Germany is not included in this figure as there is a problem with the representativeness of the German sample along the education dimension.

1. The figure shows the estimated percentage point decrease in the probability of a son to achieve tertiary education given that the son's father had achieved below upper-secondary education relative to a son whose father had upper-secondary education.

Sources: OECD calculations based on the 2005 *EU-SILC Database*, Oliveira *et al.*, 2007.

4.6. Redistributive and income support policies

Redistributive policies can alleviate financial constraints on disadvantaged families and allow them to invest in their children's human capital. Furthermore, social policies and redistributive taxes may narrow the gap between current incomes of parents, so that the incomes of their offspring could regress to the mean more quickly (Corak, 2006).[25] In this way, well-targeted redistributive policies could reduce not only current but also future inequalities. However, such policies may also lower incentives to undertake effort and invest in human capital as the net returns from these investments are reduced.

4.6.1. Taxation

One common measure of the redistributive nature of the tax system is the progressivity in the personal income tax schedule, which differs significantly across OECD countries and varies over time (Johansson *et al.*, 2007). This may reflect differences in social preferences, with strong progressivity in countries where emphasis is placed on a more even distribution of post-tax income and consumption. Cross-country estimates suggest that higher tax progressivity correlates across countries with a lower influence of parental background on their offspring's cognitive achievement in secondary education, as well as on their wages (Figures 16 and 17 in Box 8 of Causa and Chapuis, 2009; Causa *et al.*, 2009). To capture the possible effect of taxation on parents' ability to invest in their children's education, progressivity is measured at the time when the individual is a teenager. Thus, one interpretation of the positive link with student performance and wages could be that redistributive policies allow less-advantaged parents to provide their children with a better

environment, as well as with more time and resources for their education and upbringing (see below). This may facilitate learning at later stages in life, which could reduce inequality of opportunity in both higher education and wages. It is also possible that this finding reflects targeted tax cuts or tax credits (*e.g.* in-work benefits) to low-income households which, in turn, lowers the after-tax wage differential between low-income and higher-income households (*i.e.* reduces inequality).

4.6.2. Unemployment benefits

Short-term net unemployment benefits are found to be negatively associated with the influence of parental background on offspring achievement in secondary education (Figure 16 in Box 8 and Causa and Chapuis, 2009). The average unemployment benefit replacement ratio is also found to be negatively associated with intergenerational wage persistence across the European OECD countries (Figure 17 in Box 8 and Causa *et al.*, 2009). As above, unemployment benefits are measured at the time when the individual is a teenager. The policy implications of these findings are not clear, because existing empirical evidence also suggests that the presence of transfer income among parents is associated with lower wage prospects for their offspring (Corak, 2006). Moreover, some studies have found a considerable degree of intergenerational persistence in reliance on welfare, which could imply sustained cycles of welfare dependency (Page, 2004).[26] Therefore, income-support programmes are more likely to remove obstacles to intergenerational mobility if they are designed to encourage labour market participation and self-sufficiency across generations, while at the same time providing adequate income support during job search.

4.7. Housing policy

In some OECD countries housing-market outcomes encourage urban fragmentation along socio-economic lines, with a concentration of disadvantaged households in particular housing estates (OECD, 1998). Residential socio-economic segregation is often matched by schooling socio-economic segregation, primarily because a large share of students tends to go to schools in their own neighbourhood either for convenience or for regulatory reasons. As discussed above, the school environmental effect is sizeable in a number of OECD countries and tends to be larger in cities (see Causa and Chapuis, 2009). This leads to higher education and wage persistence across generations.[27] Thus, the design of housing and urban planning policies may play a role in removing obstacles to intergenerational social mobility. For example, in countries where there is a large contrast between private and social rental housing (so called "dualist rental system"), and the latter has a certain stigma, low-income households tend to cluster geographically (*e.g.* in the United Kingdom, Belgium, Japan, Australia and New Zealand), while in countries where private and social rental housing are integrated in one market (so called "unitary rental system"), segregation tends to be less pronounced (*e.g.* Sweden, Denmark and Austria; OECD, 2006b). Thus, policies aimed at increasing the social mix in neighbourhoods (for instance, by improving housing quality in deprived areas in order to attract middle-class families, OECD, 2006b) could be instrumental in improving social mobility, especially in countries where the influence of the school socio-economic environment on student performance is relatively large.

Cross-country regression results suggest that there could be potential equity and efficiency gains from increasing social mix in schools for a number of OECD countries (see Causa and Chapuis, 2009, for details). In countries suffering from high levels of school

socio-economic differences, low-skilled or disadvantaged students would benefit more from interacting with more able or advantaged students, than the latter would lose from interacting with less able students. Estimates also show that in most OECD countries there is no adverse influence, and in some cases favourable effects, of the social mix on average student performance. These results are only suggestive, but they would indicate that there is no trade-off between social mix and overall performance. Hence, implementing measures aimed at reducing school socio-economic segregation through educational policies,[28] and also through housing policies, could help to promote social mobility without hampering, and perhaps even improving, educational efficiency.

Notes

1. Economists typically analyse income or wage/earnings mobility, while sociologists focus on mobility across social class and occupations (*e.g.* Erikson and Goldthorpe, 1992, for an overview of social class mobility). One advantage of measuring intergenerational mobility by class or occupation is that data restrictions are much less stringent, retrospective information of parent's occupation being more widely available than information about their incomes, wages or earnings. A disadvantage is that it is difficult to make international comparisons of social class and occupation since they may have very different meanings across countries.
2. There is ample evidence of sizeable returns to education, both to years of schooling and cognitive achievement (*e.g.* Card, 1999; Oliveira *et al.,* 2007). Furthermore, the returns to changes in qualitative measures of education, for example test scores on cognitive achievement, seem to be higher than those from additional years of schooling (Bishop, 1992; Riviera-Batiz, 1992).
3. The wage concept in this study refers to gross hourly wages and is based on new comparable micro data across European OECD countries, the *EU-SILC database*. Gross hourly wages are based on wages and salaries paid in cash for time worked in main and secondary jobs including holiday pay and additional payments during the year preceding the interview. Given the strong persistence in wages, this is a good proxy for current wages. An hourly rate is calculated by using the current number of hours the person works in his/her main job, including overtime. Admittedly, using hours worked in the main job may lead to an over-estimation of hourly wages for persons with two or more jobs. Moreover, only wage earners are covered. This may exaggerate the degree of intergenerational wage mobility to the extent that the offspring of higher-educated families are less likely to be inactive than the offspring of low-educated families.
4. There is very little evidence concerning the intergenerational income persistence for women across OECD countries. This neglect partly reflects that in economies where women's labour-force participation rates are lower than men's, their wages may be an unreliable indicator of their economic status. In the United States, income persistence for daughters is found to be somewhat weaker than for sons, but it is still rather substantial (Chadwick and Solon, 2002).
5. Across all European OECD countries covered by the analysis, there is substantial persistence in wages of pairs of fathers and daughters. This finding is robust to the use of mother's education instead of father's education.
6. Several studies have documented the existence of non-linearities in persistence; that is, the degree of persistence in wages across generations differs along the wage distribution (*e.g.* Jäntti *et al.,* 2006; Bratberg *et al.,* 2007; Corak and Heisz, 1999; Grawe, 2004). Such non-linearities are often explained by the fact that low-income parents face credit constraints in financing their children's education, and consequently such children's wages fall below that of non-constrained children with the same ability (*e.g.* Becker and Tomes, 1986; Becker, 1989). There seems to be some suggestive evidence of the existence of non-linearities in wage persistence across a number of European countries (see Causa *et al.,* 2009, for details).
7. Differences in immigration patterns across European OECD countries could influence the patterns in wage persistence. However, in most countries covered in this study the estimates of persistence coefficients obtained, controlling for individual migration status, differ very little from those that omit this control, and the differences are statistically insignificant (see Causa *et al.,* 2009, for details).
8. There are much less comparable estimates of intergenerational persistence in wages or incomes for daughters.

9. On average across OECD countries, for each improvement of one international standard deviation in the family's socio-economic background, the student performance on the OECD PISA science scale improves by 40 points, ranging from 25 (Mexico) to 54 (France). This corresponds to a performance increase of 5% and 10%, respectively (based on an OECD average PISA performance of 500 points).

10. In Figure 7, for each country, the influence of parental background (the so-called "socio-economic gradient") is presented along with a "corrected" influence of parental background, defined as the increase in student performance associated with the move from the first to the last quartile of the country-specific distribution of student background.

11. More precisely, the school environment effect is defined as the difference in predicted PISA scores of two students with identical socio-economic backgrounds attending different schools (where the average background of students is separated by an amount equal to the inter quartile range of the country-specific school socio-economic distribution); the individual background effect is defined as the difference in predicted PISA scores of two students within a school (separated by the inter quartile range of the country-specific average within school socio-economic distribution).

12. This necessitates taking into account differences in the between and within school distribution of student socio-economic status. Hence, the comparison is made along two dimensions: both within and across countries. The approach differs from OECD (2007a) in that it is chosen to take cross-country differences in the distribution of socio-economic background into account, hence using country-specific distribution in the computations (Causa and Chapuis, 2009, for details).

13. Comprehensive school systems refer to those that do not systemically separate students according to ability or proficiency level; students follow a general unified curriculum across secondary schools.

14. For pairs of fathers and daughters, there is also a sizeable probability premium and penalty in achieving tertiary education. The cross-country pattern in the estimated probability premium for 35-44 year-old women is similar to that of men (see Causa *et al.,* 2009, for details).

15. Education persistence may be understated in France because the group of tertiary education fathers does not distinguish between having a father with a university degree and a father with a degree from a "*Grande École*". It is possible that the premium of having a father with a *Grande École* degree is higher than the premium of having a university-educated father.

16. But once existing technologies become more accessible, the importance of ability may decline and mobility may fall back to previous levels.

17. It is possible that institutions that impose wage floors (*e.g.* minimum wages or collective agreements) and compress wage distributions can in the long run force business to restructure their production, which may not necessarily lead to lower overall employment.

18. However, this effect will be mitigated to the extent that children from less-advantaged backgrounds disproportionately benefit from public spending on education (Solon, 2004).

19. In addition, higher wage differentials can also be productivity-enhancing. If wages are based on relative productivity, then workers with higher productivity (effort) will be rewarded with higher wages. This will increase equilibrium effort and lead to a positive relationship between wage dispersion and productivity. However, individual effort is reduced if wage differences are regarded as unfair (Akerlof and Yellen, 1990).

20. Both cross-country and country-specific studies have highlighted the negative impact of ability tracking on mobility (for cross-country evidence, see OECD, 2004, 2007a; Schütz *et al.,* 2005; Hanushek and Woessmann, 2005; Sutherland and Price, 2007; Duru-Bellat and Suchaut, 2005; Amermuller, 2005; for country-specific evidence, see *e.g.* Bauer and Riphahn, 2006; Pekkarinen *et al.,* 2006; Holmlund, 2006; and Bratberg *et al.*, 2005).

21. A similar result is found for the number of school programmes available to 15-year-olds, which is another measure of early differentiation in secondary education (see Causa and Chapuis, 2009, for details).

22. On average, in the OECD, around 46% of upper-secondary students are enrolled in pre-vocational or vocational programmes (OECD, 2009).

23. This summary presentation of the results does not distinguish between heterogeneous tools (spending increases, class-size reductions) that are tested in the cross-country regressions (see Causa and Chapuis, 2009, for details). In particular, while spending is clearly a poor driver of educational equity, cross-country analysis shows that reductions in class size mitigate inequalities associated with schools' socio-economic differences (*i.e.* they reduce the school environment effect). However, the education literature emphasises the difficulty of properly identifying

channels through which changes in class size have an impact on schools' contextual effects and the corresponding student outcomes, casting doubts on the effectiveness of reducing class sizes for equity purposes.

24. This finding is obtained by assessing the influence of parental background on their children's earnings at different quantiles of children's earnings distribution (so-called quantile regressions) (for details see Causa *et al.,* 2009). If financial constraints are present, the influence of parental background should be stronger in the upper quartile, since it is the more competent children from low-income families that are most likely to be financially constrained (Grawe, 2004).

25. This relies on two assumptions. First, an increase in income for parents has the same influence on their offspring regardless of its source, and second, the relationship between parent and offspring wages is linear and stable across the wage distribution.

26. A possible explanation of this phenomenon is that growing up in families that depend on welfare support reduces the stigma perceived by the offspring in getting his/her income from this source. Another possibility is that an individual living in a family receiving welfare support acquires information about the programme and its rules, thereby making it easier for her/him to collect it (Corak, 2006).

27. School environmental effects, and the so-called "neighbourhood effects", are interrelated social phenomena. In particular, school environmental effects may be one of the channels through which neighbourhood composition impacts individuals' behaviour and outcomes (*e.g.* Goux and Maurin, 2007).

28. School policies, such as school choice, can also be used as a tool to reduce residential and school segregation (see Causa and Chapuis, 2009). Cross-country research on this topic is scarce, mostly due to measurement issues. School competition may induce cream skimming, increase segregation and lead to adverse effects on disadvantaged students. However, specific experiences suggest that properly designed and equitable voucher systems can yield positive outcomes (*e.g.* the West and Peterson, 2006, study on voucher systems in Florida). Hoxby (2003) also suggests similar equity-enhancing effects of voucher and charter school programmes.

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Equity in Student Achievement Across OECD Countries: An Investigation of the Role of Policies

by
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This paper focuses on inequalities in learning opportunities for individuals coming from different socio-economic backgrounds as a measure of (in)equality of opportunity in OECD countries and provides insights on the potential role played by policies and institutions in shaping countries' relative positions. Based on harmonised 15-year old students' achievement data collected at the individual level, the empirical analysis shows that while Nordic European countries exhibit relatively low levels of inequality, continental Europe is characterised by high levels of inequality – in particular of schooling segregation along socio-economic lines – while Anglo-Saxon countries occupy a somewhat intermediate position. Despite the difficulty of properly identifying causal relationship, cross-country regression analysis provides insights on the potential for policies to explain observed differences in equity in education. Policies allowing increasing social mix are associated with lower school socio-economic segregation without affecting overall performance. Countries that emphasise childcare and pre-school institutions exhibit lower levels of inequality of opportunity, suggesting the effectiveness of early intervention policies in reducing persistence of education outcomes across generations. There is also a positive association between inequality of opportunities and income inequality. As a consequence, cross-country regressions would suggest that redistributive policies can help to reduce inequalities of educational opportunities associated with socio-economic background and, hence, persistence of education outcomes across generations.

JEL classification: I20, I21, I28, I38, H23

Keywords: education, equality of opportunity, equity in student achievement, school socio-economic segregation, public policies

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This paper focuses on inequalities in learning opportunities for individuals coming from different socio-economic backgrounds as one of the major drivers of intergenerational social mobility. It analyses cross-country differences in the extent of equality of opportunity (Romer, 1998) – the idea that individual achievement should not reflect circumstances that are beyond an individual's control, such as family socio-economic background – among OECD countries and looks at the role played by policies and institutions in shaping countries' relative positions. While there is little scope for attenuating inequalities arising from the transmission of inheritable factors, inequalities in the distribution of learning opportunities might signal economic inefficiencies that are potentially amenable to policy intervention.

The study is based on harmonised 15-year old students' achievement data available for all OECD countries through the Program for International Student Assessment (PISA). Equality in educational achievement is measured with respect to the students' socio-economic background and is used as a proxy for equality of opportunity within OECD countries.

The empirical analysis shows that OECD countries are extremely heterogeneous with respect to inequality of educational opportunities associated with family background. In particular, while Nordic European countries exhibit relatively low levels of inequality, continental Europe is characterised by high levels of inequality – in particular of schooling segregation along socio-economic lines – while Anglo-Saxon countries occupy a somewhat intermediate position. By looking at non-linearities and asymmetries arising in the effect of socio-economic background on learning opportunities, the empirical analysis also sheds light on contextual effects and the impact of school socio-economic mix.

Cross-country regression analysis can give insights on the potential for policies to explain observed differences in equity in education. Keeping in mind that estimated correlations should not be interpreted in a causal sense, empirical results suggest that a number of policies and institutions have the potential to impact upon inequality in learning opportunities. Policies allowing increasing social mix are associated with lower school socio-economic segregation without affecting overall performance, at least in countries where such segregation is relatively high, as in continental Europe. Schooling differentiation and early tracking policies are found, as in earlier studies, to increase socio-economic inequality in learning opportunities. There is mixed evidence on the impact of public education spending on equality of learning opportunities, but empirical results suggest that financial incentives to teachers and effective mechanisms for allocating public resources to schools might help increase equality of opportunities in educational achievement. Countries that emphasise childcare and pre-school institutions exhibit lower levels of inequality of opportunity, suggesting the effectiveness of early intervention policies in reducing persistence of education outcomes across generations. There is also a positive association between inequality of opportunities and income inequality. As a consequence, cross-country regressions suggest that redistributive policies can help to reduce inequalities of educational

opportunities associated with socio-economic background and, hence, persistence of education outcomes across generations. Finally, there is some empirical evidence suggesting a role for labour and social policies in shaping cross-country differences in the impact of socio-economic background on student achievement.

The document is organised as follows. Section 1 provides the motivation and background underlying the analysis, by illustrating the link between educational equality of opportunity and intergenerational social mobility. Section 2 presents and discusses the estimated impact of parental background on secondary educational achievement on a country-by-country basis, focusing on different dimensions of equality of learning opportunities. Section 3 relates the patterns observed across OECD countries to differences in their institutional settings, by focusing on educational and early intervention policies, as well as welfare, redistribution, and labour market policies. Before presenting the empirical results, the section provides a brief overview of the comparable studies that have focused on the relationship between institutions and equality of opportunity.

1. Motivation and background

The idea that education is one of the main drivers of intergenerational social mobility has been formally modelled under various assumptions. The theoretical framework is based on models of intergenerational transmission of inequality and allocation of resources within the family, which have led to a close focus on the role of human capital and education policy (Becker and Tomes, 1979, 1986). These models were further developed by Solon (2004), who integrated public and private investment in education into a single framework. Restuccia and Urrita (2004) studied intergenerational human capital transmission focusing on innate ability, early education, and college education, and the implications for early and college education policies. In addition, Heckman (2007) emphasised the importance of human capital investment at the right time in the lifecycle in order to correct for disadvantageous individual conditions inherited from parents.

There is ample empirical evidence that education is one of the major drivers of intergenerational social mobility, particularly income mobility. Among others, Machin (2004) and Blanden *et al.,* (2004) argue that the recorded fall in intergenerational mobility in the United Kingdom between the cohorts born at the end of the 1950s and those born in the 1970s was, to a large extent, due to the fact that increased educational opportunities in the reference period disproportionately benefited individuals from better-off backgrounds.

The estimation of economic returns to education has been the object of numerous empirical contributions.[1] Topical studies (Card, 1999, Ashenfelter *et al.,* 1999) have documented substantial earnings returns to quantitative measures of education, such as years of schooling. The earnings returns to qualitative measures of education, like test scores on cognitive achievement, seem to be even higher (Bishop, 1992, Riviera-Batiz, 1992), and, contrary to quantitative measures, increasing with an individual's time on the labour market (Altonji and Pierret, 2001). The results of these studies suggest that qualitative measures of education are relevant for assessing individual future economic success.

The development of cognitive skills tends to be stronger early on in life. Therefore, intergenerational mobility studies have devoted attention to the relationship between children's cognitive skills and parental background as an important early indicator of (dis)advantage. In this respect, empirical research that relates ability test scores of children to the socio-economic background of parents (see Heckman, 1995) suggests that the link

emerges at a young age.[2] Against this background, the present empirical study focuses on the impact of parental background on adolescents' test scores as an indicator of equity in education and, in this respect, a measure of intergenerational social mobility.[3]

The OECD has adopted a consistent approach for measuring equality of educational opportunities (OECD, 2001a, 2004, 2007a). It also produced a specific publication on factors related to quality and equity through the use of the 2000 PISA database (OECD, 2005a). PISA results highlight substantial differences across OECD countries. In particular, while Nordic European countries, as well as Canada and Australia, appear to display relatively high levels of educational equity, other countries, notably in continental (Germany, Austria, Belgium, France) and southern Europe (Italy in particular), are characterised by relatively low levels of educational equity.[4] This cross-country picture appears to have been stable over the period covered by PISA surveys, with no deterioration of measured equity in student achievement in OECD countries between 2000 and 2006.

2. Equity in student achievement across OECD countries

2.1. The PISA dataset[5]

This study uses cross-country comparable microeconomic data on student achievement, collected consistently across and within OECD countries through the Programme for International Student Assessment (PISA), which assesses the skills of students approaching the end of compulsory education. It targets the 15-year-old student population in each country and independently of how many years of schooling are foreseen for 15-year-olds by the structure of the national school systems. It was conducted in a total of 67 countries, including all OECD countries. The PISA 2006 survey assesses the mathematical, scientific, and reading literacy as well as the problem-solving skills of the student population in each participating country.

The PISA sampling procedure ensures that a representative sample of the target population is tested in each country. Most countries employ a two-stage sampling procedure. The first stage draws a random sample of schools in which 15-year-old students are enrolled. In most countries, the probability of each school being selected is proportional to its size, as measured by the estimated numbers of 15-year-old students enrolled in the school. The second stage randomly samples 35 of the 15-year-old students in each of these schools, with each 15-year-old student in a school having equal selection probability. The empirical analysis undertaken in what follows explicitly takes into account the complex survey design of the data, as well as its probabilistic structure.

The main focus of the PISA 2006 study is on scientific literacy, with about 70% of the testing time devoted to this item. Given the very high correlation among science, mathematics, and reading scores, the following analysis focuses on science scores. OECD (2007a) points to the robustness of country-specific and cross-country empirical assessments to the use of either score. PISA uses item response theory scaling and calculates five plausible values for proficiency in each of the tested domains for each participating student. The performance in each domain is mapped on a scale with an international mean of 500 and a standard deviation of 100 test-score points across OECD countries.[6] To simplify the empirical analysis, in this paper it was decided to focus on one – specifically, the first – of the five individual's plausible values. This procedure is superior to the *ex ante* averaging of all values (OECD, 2005c). Not surprisingly, results are robust to the use of either of them as a dependent variable.

The PISA dataset provides a rich array of background information on each student, as well as on his/her school. In separate background questionnaires, students are asked to provide information on their personal characteristics and family background, and school principals provide information on their schools, resource endowments and institutional settings.

2.2. Measuring equity in student achievement: definitions and methodology

Equity in student achievement is defined consistently with the concept of equality of opportunity. The empirical counterpart to the concept is constructed by estimating how strongly educational achievement, as measured by PISA test scores, depends on the socio-economic background of the students' families in each country. Specifically, the analysis uses the Index of Economic, Social, and Cultural Status (ESCS) provided by PISA as the measure of family background. The size of the achievement difference between students with high and low values of the ESCS index provides a measure of how fair and inclusive each school system is: the smaller the difference, the more equally distributed is education. This methodology is standard in the empirical literature using cross-country educational datasets (OECD PISA reports 2001a, 2004, 2007a; Schutz *et al.,* 2005, Schutz *et al.,* 2007, Woessmann, 2004, d'Addio, 2007).

The PISA ESCS index is intended to capture a range of aspects of a student's family and home background. It is explicitly created in a comparative perspective by PISA experts with the goal of minimising potential biases arising as a result of cross-country heterogeneity (OECD, 2005b). It is derived from a Principal Component Analysis applied to the following variables: *i)* the international socio-economic index of occupational status of the father or mother, whichever is higher; *ii)* the level of education of the father or mother, whichever is higher, converted into years of schooling; *iii)* the PISA index of home possessions obtained by asking students whether they had at their home a number of items allowing and facilitating learning (*inter alia*, a desk at which to study, a computer, books ...).[7] The student scores on the index are standardised to have an OECD mean of zero and a standard deviation of one.[8]

2.3. Equity in student achievement across OECD countries: the results

Regression estimates suggest that there are substantial differences among OECD countries in terms of equality of learning opportunities. Causa and Chapuis (2009) present detailed findings on a country-by-country basis. Part of the results confirm and reflect previous OECD findings (OECD, 2007a). In this paper, previous OECD work is extended with further empirical results on country-specific patterns of equity in the distribution of learning opportunities among students and schools.

2.3.1. Socio-economic segregation and equity in student achievement in OECD countries

We investigate how student performance is separately affected by student's own family background and the average socio-economic background of families of other students in the same school, *i.e.* the school socio-economic environment. Separating these two effects allows a better understanding of how learning opportunities are distributed both within and across schools. In turn, this facilitates exploration of how equality of learning opportunities is related to differences in policies and institutions across OECD countries.

2.3.1.1. Individual background and school environment effects: definition and empirical approach. The baseline empirical model focuses on the estimation of the so-called "socio-economic gradient", β that is the influence of parental background on achievement. Hence, the student-level score is regressed upon his/her family socio-economic background:

$$Y_{isc} = \alpha_{1c} + \beta_{1c} \cdot F_{isc} + \varepsilon_{isc} \quad (1)$$

where index *i* refers to individual, *s* to school, and *c* to country. Y_{isc} denotes the student's science test score, F_{isc} denotes family background as measured by the ESCS index, and ε_{isc} is an error term.

The overall socio-economic gradient can be decomposed in two parts, a "within-school" gradient – or individual background effect – and a "between-school" gradient – or school environment effect. The former can be defined as the relationship between student socio-economic background and student performance within a given school, while the latter can be defined as the relationship between the average socio-economic status of the school and student performance, controlling for his/her background. As explained in OECD, (2004, 2007a), the decomposition of the overall gradient is a function of the between-school gradient, the average within school gradient, and a "segregation" parameter that measures the proportion of variation in socio-economic background that is between schools (OECD, 2007a).[9]

The empirical approach for estimating the influence of individual background and school environment on students' test scores is an extension of equation (1):

$$Y_{isc} = \alpha_{1c} + \beta_{wc} \cdot F_{isc} + \beta_{bc} \cdot \overline{F_{sc}} + \varepsilon_{isc} \quad (2)$$

where $\overline{F_{sc}}$ is defined as the weighted average (by student sampling weights) of student socio-economic background in the school attended by individual *i* (which is computed excluding the student himself).[10] The baseline empirical model focuses on the estimation of the so-called "socio-economic gradient", β that is the influence of parental background on achievement. Hence, while β_{wc} refers to the within-school gradient, β_{bc} refers to the between-school gradient. Equation (2) can be extended to control for student and school-level characteristics.

2.3.1.2. Interpreting school environment effects. Estimation of the school environment effect, or parameter β_{bc}, is a topical question in educational research. Box 1 provides a brief summary of the underlying conceptual framework. Broadly speaking, this parameter captures two interrelated effects: *i*) contextual effects, arising when student achievement depends on the socio-economic composition of his/her reference group (which is exogenous to this group's behaviour); *ii*) peer effects, arising when student achievement depends on that of his/her reference group (*i.e.* on the behaviour of other members of the group).

In this study, the between-school socio-economic gradient estimated in equation (2) can be considered as a proxy for the contextual effect arising in the school. It is not possible to apportion the contribution of peer effects to this estimate. Indeed, as recalled in Box 1, contextual and peer effects are difficult to identify separately. Moreover, a number of caveats apply to this analysis, among which the most important is self-selectivity, whereby wealthier and more skilled students choose a better school and peer group, causing an over-estimation of contextual effects. This bias does not appear to be important in the present context, given that the estimated contextual effects are robust to the introduction of school level controls – such as various measures of school characteristics, resources, and

Box 1. **School environment effects: methodological issues and policy implications**

The literature on social interactions at school is abundant and results are controversial.* Manski (1995, 2000) provides a framework for a systematic analysis of social interactions. He states three possible reasons why individuals belonging to the same group might tend to behave alike: *i)* endogenous effects, also called peer effects: the probability that an individual behaves in some way is increasing with the presence of this behaviour in the group; that is, student achievement depends positively on the average achievement in the reference group; *ii)* contextual effects: the probability that an individual behaves in some way depends on the distribution of exogenous background characteristics in the group; that is, student achievement depends on the socio-economic composition of the reference group; *iii)* correlated effects: individuals behave in the same way because they have similar background characteristics and face similar environments.

Peer and contextual effects refer to externalities and are driven by social interactions; correlated effects are a non-social phenomenon. Contextual and peer effects cannot be separated empirically due to identification problems, first of all multicollinearity. Moreover, the investigation of peer effects faces a classical simultaneity problem because a student both affects his/her peers and is in turn affected by them. One of the solutions advocated by scholars to overcome this issue is that of estimating contextual effects – that is, the effect of group's socio-economic composition on student achievement. Endogeneity bias is reduced by excluding the student from the average socio-economic background of the group.

Peer and contextual effects are of policy relevance because they can serve as a basis for reallocating students into different schools or environments. The argument is that weak students would benefit if they were in the same class as high-performing students. However, increasing equity in this way potentially threatens overall efficiency in terms of average cognitive achievement at the class, school or even country level. In order to be efficiency-enhancing, in the sense of increasing average cognitive development of students, two conditions have to be met. First, peer effects should be higher for low-skilled students than for high-skilled ones, and second, higher mix in schools should not have detrimental effects on average learning in the group. These topics have been analysed in the educational and economic literature on peer effects, whose main results can be summarised as follows:

- Peer effects are sizeable, both at the primary and secondary levels (Amermuller and Pischke, 2003, Hanushek *et al.,* 2003, Vidgor and Nechyba, 2004, Schneeweis and Winter-Ebmer, 2005), as well as at the tertiary level (Sacerdote, 2000, Winston and Zimmerman, 2003).
- Peer effects are asymmetric, and favour weaker students. This result is slightly more controversial, although most studies find that peer effects are stronger – more positive – for low-ability students (Schindler, 2003, Levin, 2001, Sacerdote, 2000, Winston and Zimmerman, 2003, Schneeweis and Winter-Ebmer, 2005).
- Asymmetries in favour of weaker students have to be weighted against the potential negative effects of within-class mix. The literature is controversial in that respect, although a number of studies have found no impact of mix on student performance (Hanushek *et al.,* 2003, Schindler, 2003, Vidgor and Nechyba, 2004, Schneeweis and Winter-Ebmer, 2005).

* See Brock and Durlauf (2001), Moffitt (2001), Hanushek *et al.,* (2003).

funding,[11] as well as school selection of students on the basis of past achievement.[12, 13] Regressions also control for a number of family characteristics that are likely to downplay this effect, first of all, own socio-economic background. Furthermore, the potential upward bias induced by self-selectivity might be somewhat compensated by the potential downward bias arising because of the impossibility of estimating contextual effects at the class level. Indeed, PISA data do not contain information on students' classes. The educational literature stresses that contextual and peer effects are higher at the class than at the school level (see Vidgor and Nechyba, 2004), a finding that would suggest a potential under-estimation of social interactions effects in the PISA data.

Although properly measuring, quantifying, and characterising peer and contextual effects is beyond the scope of the present study (not least because of data unavailability at the class level), comparing estimates of these effects across countries can provide interesting insights. There need not be *a priori* systematic differences across countries in terms of social interaction effects; and similarly there need not be *a priori* systematic differences across countries in terms of estimation biases. Therefore, the observed *ex post* distribution of estimated school environment effects across OECD countries might, to a large extent, reflect differences in policies and institutions. For instance, higher estimated school environment effects can be interpreted as resulting from policies and institutions that induce higher segregation along socio-economic lines and, therefore, lower levels of social mix. Cross-country studies are rare on this subject. One exception is Entorf and Lauk (2006), who use a comparative approach based on PISA 2000 data, and estimate peer effects for different groups of countries, depending on schooling systems and immigration patterns. They find sizeable differences across groups of countries, and conclude that non-comprehensive and ability-differentiated school systems exhibit the highest levels of peer effects.[14]

2.3.1.3. Individual background and school environment effects in OECD countries: the results. Based on the regression results reported in Table 1, Figure 1 compares the estimated individual background and school environment effects across countries. Box 2 provides details on the methodology used for this comparison and on the differences with the approach used in the 2007 PISA report. The figure illustrates *i)* the estimated between-school effect, or school environment effect, defined as the gap in predicted scores of two students with identical socio-economic backgrounds attending different schools (where the average background of students is separated by an amount equal to the inter-quartile range of the country-specific school socio-economic distribution); *ii)* the estimated within-school effect, or individual background effect, defined as the gap in predicted scores of two students within the same school coming from different family backgrounds (where the family backgrounds are separated by an amount equal the inter-quartile range of the country-specific average within school socio-economic distribution). While the first effect refers to the increase in a student's score obtained from moving the student from a school where the average socio-economic intake is relatively low to one where the average socio-economic intake is relatively high, the second refers to the increase in student's score obtained from moving the student from a relatively low socio-economic status family to a relatively high socio-economic status family, while he/she stays in the same school. The numbers presented in Figure 1 should not be taken at face value and are only indicative of the ranking of OECD countries in terms of individual and school environment effects.

In all OECD countries, there is a clear advantage in attending a school where students are, on average, from more advantaged socio-economic backgrounds. Some countries

Table 1. **Estimates of the socio-economic gradient in OECD countries: school environment and individual background effects**

Impact of parental background on PISA science scores of teenagers

	Australia	Austria	Belgium	Canada	Czech Republic	Denmark	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Japan
Individual background	30.424***	16.279***	20.645***	25.679***	24.097***	33.675***	30.330***	23.415***	19.535***	19.268***	11.205***	28.341***	30.177***	10.885***	8.987***
	[1.405]	[1.661]	[1.032]	[1.297]	[1.570]	[1.523]	[1.498]	[1.774]	[1.179]	[1.471]	[1.434]	[1.857]	[1.722]	[1.012]	[1.965]
School environment	53.140***	103.910***	101.220***	39.427***	110.141***	36.766***	11.972**	98.903***	107.591***	59.354***	82.570***	–6.836	43.813***	75.631***	125.737***
	[4.244]	[6.053]	[5.052]	[4.464]	[6.855]	[6.943]	[5.716]	[4.683]	[5.297]	[4.981]	[4.884]	[4.142]	[5.253]	[5.158]	[8.698]
Constant	510.484***	487.508***	490.381***	512.577***	509.669***	475.406***	553.324***	508.298***	480.865***	485.832***	512.492***	474.953***	510.543***	526.669***	534.546***
	[1.512]	[3.285]	[2.594]	[2.427]	[3.335]	[3.110]	[1.946]	[3.164]	[2.887]	[2.528]	[2.660]	[3.451]	[2.114]	[4.650]	[3.090]
Number of observations	13 995	4 908	8 777	22 132	5 902	4 496	4 697	4 606	4 686	4 861	4 462	3 733	4 501	21 678	5 862
R-squared	0.147	0.348	0.387	0.107	0.314	0.160	0.085	0.388	0.421	0.249	0.410	0.063	0.158	0.316	0.236

	Korea	Luxembourg	Mexico	Netherlands	New Zealand	Norway	Poland	Portugal	Slovak Republic	Spain	Sweden	Switzerland	Turkey	United Kingdom	United States
Individual background	11.492***	24.889***	7.947***	14.972***	42.907***	30.925***	36.362***	18.534***	23.251***	24.636***	34.299***	29.721***	10.755***	34.645***	35.111***
	[1.694]	[1.089]	[0.749]	[1.175]	[1.768]	[1.798]	[1.483]	[1.187]	[1.689]	[1.187]	[2.335]	[1.401]	[1.121]	[1.983]	[1.726]
School environment	80.049***	70.134***	35.939***	120.000***	50.897***	29.559***	15.842***	30.693***	64.124***	21.949***	33.414***	75.539***	65.692***	65.766***	51.149***
	[7.950]	[2.281]	[2.183]	[5.317]	[5.452]	[8.123]	[5.289]	[3.233]	[7.216]	[2.638]	[7.546]	[5.971]	[4.937]	[4.704]	[7.092]
Constant	522.712***	478.659***	453.385***	491.176***	522.973***	463.253***	513.414***	504.485***	501.467***	503.282***	489.080***	502.251***	521.766***	498.342***	477.770***
	[2.573]	[1.126]	[2.207]	[2.819]	[2.311]	[4.967]	[2.473]	[2.292]	[2.172]	[1.862]	[2.858]	[2.022]	[7.599]	[2.028]	[3.102]
Number of observations	5 168	4 488	30 869	4 838	4 727	4 601	5 502	5 091	4 723	19 499	4 386	12 136	4 934	12 806	5 568
R-squared	0.193	0.336	0.262	0.439	0.194	0.084	0.151	0.214	0.288	0.152	0.119	0.249	0.344	0.189	0.218

Notes: Regression of student science performance on student PISA index of economic, social and cultural status (ESCS), and school-level ESCS (average across students in the same school, excluding the individual student for whom the regression is run). Regressions for Italy include regional fixed effects. Country-by-country least-square regressions weighted by student sampling probability. Robust standard errors adjusted for clustering at the school level.

Example: In Australia, for each improvement of one international standard deviation in the individual socio-economic background, student performance on the OECD PISA science scale improves by 30 points, within a given school socio-economic environment. In Australia, for each improvement of one international standard deviation in the school socio-economic environment, student performance on the OECD PISA science scale improves by 53 points, for a given level of individual socio-economic background.

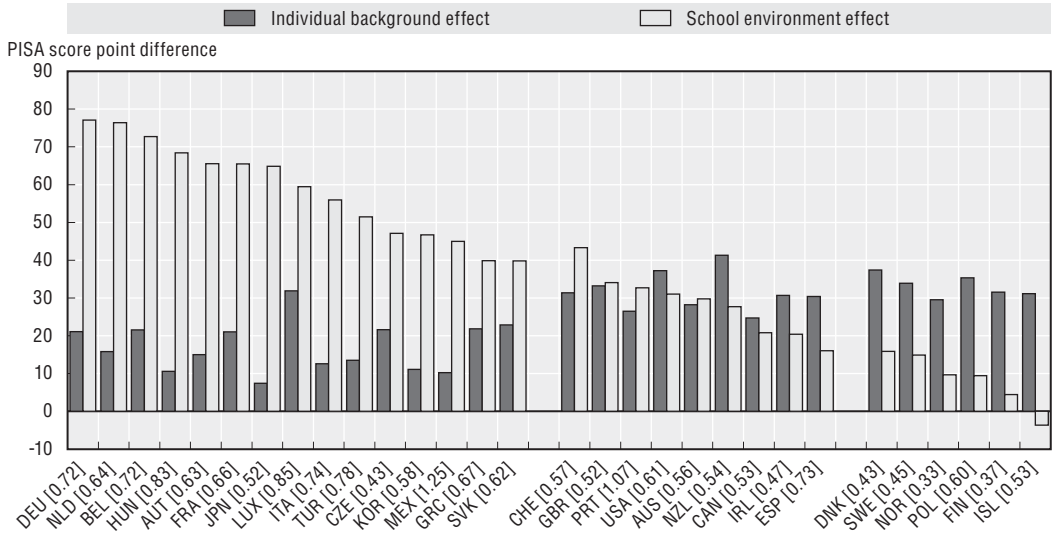
Balanced repeated replicate variance estimation, standard errors clustered by school in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions include a constant.

Source: OECD calculations based on the 2006 *OECD PISA Database*.

Figure 1. **Effects of individual background and school socio-economic environment on students' secondary achievement**[1]

Socio-economic gradient taking cross-country distributional differences into account

Differences in performance on the science scale associated with the difference between the highest and the lowest quartiles of the country-specific distribution of the PISA index of economic, social and cultural status



Notes: The individual background effect is defined as the difference in performance on the PISA science scale associated with the difference between the highest and the lowest quartiles of the average individual background effects distribution of the PISA index of economic, social and cultural status, calculated at the student level. The school environment effect is defined as the difference in performance on the PISA science scale associated with the difference between the highest and the lowest quartiles of the country-specific school level average distribution of the PISA index of economic, social and cultural status, calculated at the student level.

Data in parentheses are values of the difference between the highest and the lowest quartiles of the country-specific school-level average distribution of the PISA index of economic, social and cultural status, calculated at the student level.

The negative school environment effect for Iceland is not statistically significant.

1. Regression of student science performance on student family socio-economic background (as measured by PISA ESCS), and school-level socio-economic background (average PISA ESCS across students in the same school, excluding the individual student for whom the regression is run). Country-by-country least-square regressions are weighted by student sampling probability. Robust standard errors adjusted for clustering at the school level. Regressions for Italy include regional fixed effects.

Source: OECD calculations based on the 2006 *OECD PISA Database*.

exhibit substantial inequalities associated with school attendance: this is, for instance, the case of Germany or France, where moving a student from a low socio-economic environment school to a high socio-economic environment school would produce a 73 and 65 points difference respectively, compared with 14 in Sweden and 15 in Denmark.[15] These cross-country patterns confirm earlier findings, in particular when comparing comprehensive school systems – such as in Nordic European countries – and non-comprehensive systems – such as in Austria and Germany (see in particular OECD PISA reports, but also Fuchs and Woessmann, 2004, Entorf and Lauk, 2006).

Box 2. **Individual's background and school environment effects in OECD countries**

The regression results presented in Table 1 suggest that, on average across OECD countries, for each improvement of one standard deviation in student socio-economic background within a given school environment, the student performance on the science scale improves by 24 points, with cross-country differences ranging from 9 advantage points (Italy) to 43 (New Zealand). The impact of the school socio-economic background is estimated to be substantially higher: on average across OECD countries, for each improvement of a student-level standard deviation in the average school socio-economic background, the student performance on the science scale improves by 62 points, independent of his/her own socio-economic background, with cross-country differences ranging from 11 advantage points (Finland) to 126 (Japan).[1]

Based on these raw estimates, the effects of an individual's background and a school's environment can be adjusted for more meaningful cross-country comparisons using the same approach as in the PISA 2007 report (OECD, 2007a), which accounts for the impact of the within-country distribution of students' socio-economic status. However, the approach in this study departs from OECD (2007a) in one respect: cross-country differences in the distribution of students' socio-economic status are taken into account using country-specific within and between distributions in the computations. Hence, the comparison is made both within and across countries. This requires calculating, for each country, the school-level distribution of socio-economic background, as well as the average within-school distribution of socio-economic background, based on student-level data. Such concepts allow measuring consistently the effects associated with relevant moves along both the within and between-school distributions.[2]

1. In Iceland, the estimated negative within effect is not statistically significant (see Table 1).
2. Intuitively, the overall distribution of socio-economic status can be decomposed into the between and within school components. Given that each school is mixed in terms of its socio-economic intake, differences in the average of schools' socio-economic backgrounds are naturally smaller than comparable differences between individual students.

2.3.1.4. School environment effect along the school socio-economic distribution. The effect of the school socio-economic environment on educational achievement is not always uniform within the school socio-economic distribution. Table 2 presents results from a regression specification that accounts for possible non-linearities in the effect of socio-economic background by simply introducing square terms of individual and school socio-economic variables (equation 3):

$$Y_{isc} = \alpha_{1c} + \beta_{1wc} \cdot F_{isc} + \beta_{1bc} \cdot \overline{F_{sc}} + \beta_{2wc} \cdot F_{isc}^{\ 2} + \beta_{2bc} \cdot \overline{F_{sc}}^{2} + \varepsilon_{isc} \quad (3)$$

In some countries, there are large differences in the between-school gradient for students attending schools at the top and those attending schools at the bottom deciles of the school distribution of socio-economic background. For example, in the United Kingdom it is the very "rich" schools that make a difference, providing a relatively high pay-off to students attending schools where the average student is socially advantaged, independent of their individual background. Conversely, in France and Germany it is the very "poor" schools that make a difference and provide a relative high penalty to students attending schools where the average student is socially disadvantaged, independent of their own individual background.[16]

Table 2. **Estimates of the socio-economic gradient in OECD countries: non-linearities in the impact of socio-economic background**

Impact of parental background on PISA science scores of teenagers

	Australia	Austria	Belgium	Canada	Czech Republic	Denmark	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Japan
Individual background	30.455***	12.712***	18.767***	26.892***	23.687***	28.609***	27.516***	23.148***	16.501***	19.756***	9.764***	28.717***	30.740***	9.681***	8.866***
	[1.429]	[2.002]	[1.075]	[1.556]	[1.559]	[1.694]	[1.552]	[1.852]	[1.632]	[1.518]	[1.471]	[3.088]	[1.658]	[1.151]	[2.078]
Individual background squared	–3.324***	–3.497***	–0.139	–3.091**	–4.097***	1.472	2.002	2.023	–0.850	–3.055**	–2.023**	–1.180	0.059	–2.492***	–5.991***
	[1.218]	[1.243]	[0.753]	[1.189]	[1.547]	[1.164]	[1.396]	[1.503]	[0.990]	[1.191]	[0.945]	[1.555]	[1.280]	[0.750]	[1.974]
School environment	48.585***	108.204***	95.736***	45.289***	108.844***	39.820***	–2.942	93.726***	111.147***	53.877***	84.888***	–18.107	46.470***	73.651***	123.128***
	[6.288]	[9.085]	[5.827]	[8.242]	[7.528]	[8.039]	[9.541]	[4.798]	[6.999]	[4.234]	[5.479]	[12.146]	[4.477]	[5.222]	[8.995]
School environment squared	7.383	–15.011	–8.552	–6.842	8.375	–5.234	29.462**	–27.038***	–16.974**	–19.242***	–6.401	9.468	–24.051***	–13.090**	–18.216
	[8.373]	[11.481]	[8.107]	[7.657]	[10.087]	[11.369]	[11.966]	[8.579]	[8.102]	[4.312]	[6.384]	[9.030]	[6.620]	[6.126]	[20.363]
Female student	–1.403	–14.573***	–6.368**	–7.409***	–11.935**	–7.462**	0.694	–7.634**	–10.913***	7.614**	–19.596***	5.438*	–1.121	–11.888***	–5.050
	[2.351]	[4.101]	[2.670]	[1.831]	[4.654]	[2.851]	[2.819]	[3.042]	[2.303]	[3.795]	[3.029]	[3.113]	[3.035]	[2.704]	[5.162]
Migration background: first generation	1.950	–28.747***	–14.402***	–9.271**	–54.888***	–30.276***	–60.102**	–17.741**	–26.164***	–16.677	–45.038***	–19.355	–11.445	–47.480***	3.550
	[3.819]	[8.642]	[5.270]	[4.299]	[17.018]	[11.049]	[26.607]	[7.884]	[7.168]	[12.852]	[14.137]	[22.670]	[13.954]	[16.834]	[36.562]
Migration background: second generation	–1.199	–32.774***	–39.543***	–22.227***	–26.632**	–23.683**	–72.923***	–35.993***	–19.135***	–4.006	–3.561	–35.513*	20.781**	–55.573***	38.963
	[4.020]	[7.256]	[7.709]	[5.107]	[12.490]	[9.957]	[16.538]	[9.665]	[6.109]	[8.780]	[9.748]	[20.424]	[9.298]	[10.123]	[30.478]
Foreign language spoken at home	–13.967**	–25.553***	–22.782***	–1.995	–4.881	–37.087***	–16.383	4.734	–29.044***	–25.012**	–25.799**	–36.258**	–74.552***	–5.563	–119.733***
	[5.629]	[7.868]	[5.122]	[5.311]	[14.679]	[9.219]	[13.905]	[7.717]	[5.380]	[9.667]	[11.551]	[15.142]	[13.177]	[11.257]	[20.796]
Number of observations	13 573	4 760	8 026	21 285	5 787	4 268	4 624	4 453	4 187	4 581	4 408	3 658	4 404	18 640	5 638
R-squared	0.148	0.385	0.395	0.115	0.316	0.173	0.099	0.397	0.439	0.276	0.423	0.071	0.173	0.328	0.239

Table 2. **Estimates of the socio-economic gradient in OECD countries: non-linearities in the impact of socio-economic background** *(cont.)*

Impact of parental background on PISA science scores of teenagers

	Korea	Luxembourg	Mexico	Netherlands	New Zealand	Norway	Poland	Portugal	Slovak Republic	Spain	Sweden	Switzerland	Turkey	United Kingdom	United States
Individual background	11.485***	16.703***	10.479***	11.656***	41.821***	30.286***	36.394***	19.184***	23.129***	22.520***	31.233***	22.038***	17.258***	34.560***	33.355***
	[1.725]	[1.496]	[0.913]	[1.213]	[2.015]	[2.177]	[1.492]	[1.295]	[1.561]	[1.106]	[1.949]	[1.457]	[2.665]	[2.009]	[1.765]
Individual background squared	1.684	–0.656	1.519***	0.818	2.731	–2.964**	–0.042	0.666	–5.143***	–3.403***	–0.106	0.926	3.069***	–2.397*	2.909**
	[1.379]	[0.770]	[0.390]	[1.200]	[1.663]	[1.402]	[1.040]	[0.679]	[1.472]	[0.870]	[1.443]	[0.897]	[0.952]	[1.347]	[1.219]
School environment	80.094***	65.910***	37.046***	121.846***	51.600***	10.323	26.150***	25.056***	73.009***	22.855***	41.060***	75.236***	85.129***	48.701***	47.129***
	[8.433]	[2.899]	[3.180]	[7.444]	[6.130]	[19.271]	[5.679]	[2.417]	[4.910]	[2.508]	[12.527]	[5.663]	[9.625]	[5.900]	[9.080]
School environment squared	–10.571	2.296	1.672	–8.365	–2.840	23.063	27.676***	–6.928***	19.106***	3.330	–17.003	–0.674	8.794**	30.976***	–3.018
	[13.341]	[4.205]	[1.300]	[10.049]	[9.326]	[15.964]	[6.700]	[2.349]	[5.821]	[3.638]	[17.573]	[8.467]	[3.689]	[9.907]	[10.742]
Female student	2.761	–6.505**	–10.398***	–11.217***	–0.011	2.649	–1.000	–2.871	–9.096**	–5.218***	–0.393	–11.244***	4.097	–8.739***	–2.929
	[4.033]	[2.583]	[1.772]	[2.584]	[3.602]	[3.281]	[2.323]	[2.368]	[3.477]	[1.889]	[2.760]	[1.959]	[3.540]	[2.212]	[2.865]
Migration background: first generation	38.128***	–21.944***	–35.831***	–21.920***	–9.063	–29.104**	37.656	–52.736***	–30.009	–2.889	–15.634*	–39.658***	–19.343	–3.700	1.303
	[3.367]	[4.272]	[8.825]	[7.793]	[5.537]	[11.708]	[62.558]	[9.919]	[19.767]	[11.371]	[8.437]	[3.974]	[16.232]	[6.308]	[7.148]
Migration background: second generation	0.000	–21.579***	–74.390***	–25.141***	–8.761	–19.686	–99.875**	–61.677***	–29.207	–49.289***	–33.838***	–54.872***	11.176	–13.699	–3.287
	[0.000]	[4.783]	[6.485]	[8.795]	[5.451]	[13.661]	[49.676]	[8.341]	[33.640]	[6.354]	[9.835]	[5.582]	[11.586]	[9.258]	[8.698]
Foreign language spoken at home	–14.001	–22.048***	25.977	–14.347**	–31.190***	–16.938	–0.254	–0.246	–16.937	–2.035	–26.548***	–25.287***	5.085	–11.795	–19.874***
	[25.738]	[4.379]	[23.447]	[6.695]	[6.196]	[10.569]	[16.061]	[8.358]	[22.092]	[12.300]	[6.775]	[4.757]	[10.543]	[9.210]	[5.985]
Number of observations	5 059	3 981	29 715	4 690	4 524	4 488	5 354	4 880	4 621	18 861	4 256	11 347	4 784	12 430	5 311
R-squared	0.195	0.356	0.280	0.446	0.203	0.092	0.160	0.243	0.303	0.175	0.142	0.320	0.364	0.194	0.212

Notes: Regression of student science performance on student ESCS, student ESCS squared, individual control variables (gender, migration status and language spoken at home), school-level ESCS (average across students in the same school, excluding the individual student for whom the regression is run), and school-level ESCS squared. Regressions for Italy include regional fixed effects. Country-by-country least-square regressions weighted by student sampling probability. Robust standard errors adjusted for clustering at the school level.
Balanced repeated replicate variance estimation, standard errors clustered by school in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: OECD calculations based on the 2006 *OECD PISA Database*.

2.3.1.5. Educational inequality and socio-economic differences in rural an urban areas.

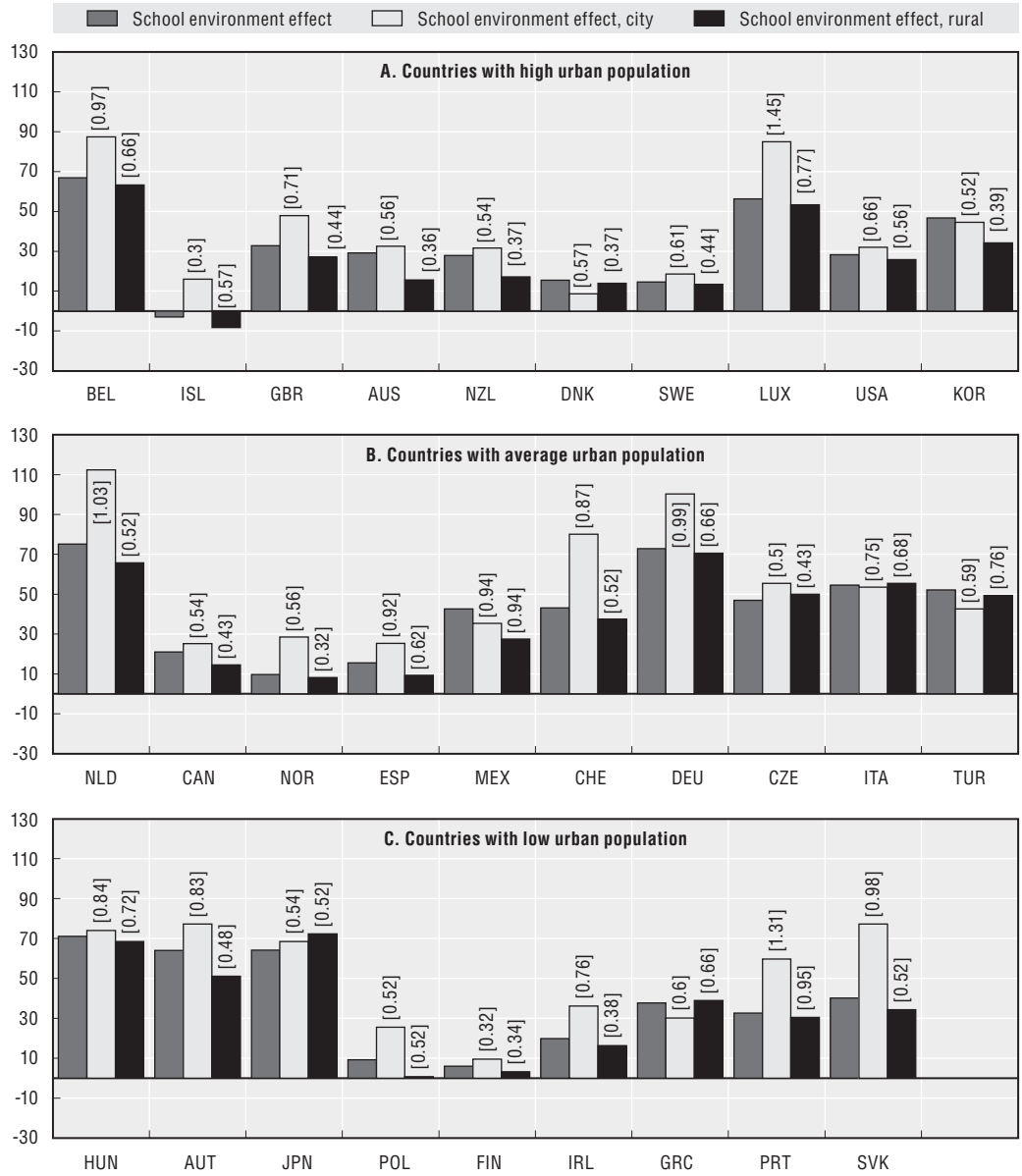
Taking distributional differences into account, Figure 2 compares the effect of school environment on student performance in rural and urban areas. It shows the differences in performance on the PISA science scale associated with the difference between the highest and the lowest quartiles of the country-specific distribution of the school average PISA ESCS index. One limitation of this analysis is that, due to data limitations, the threshold between urban and rural has been arbitrarily fixed at 100 000 inhabitants for all countries, ignoring possible country specificities in this respect. However, the figure distinguishes groups of countries, based on their proportion of urban population (where the definition of "urban" is country-specific). The values of the inter-quartile range of the distribution of the school-average PISA ESCS index, for rural and urban areas are reported in parentheses.

The corresponding regressions, run separately for urban and rural areas, are presented in Tables 3a and 3b.[17] The analysis suggests that in many countries school socio-economic segregation might, to a large extent, be concentrated in cities. However, for most of the countries covered by the analysis, this finding is not the result of (statistically) significant differences in the estimated school environment effects across urban and rural areas, but rather of the substantial differences in the distribution of schools by socio-economic background across urban and rural areas.[18] Indeed, the school socio-economic distribution is much wider in cities than in rural areas: it is, for example, around twice as wide in Luxembourg, the Netherlands, Germany and Belgium.[19] These countries also have some of the highest estimated levels of overall school environment effects (adjusted or unadjusted for distributional cross-country differences).

2.3.1.6. Asymmetries and the impact of social heterogeneity. Empirical results indicate that contextual and peer effects are stronger for low-skilled students in a number of OECD countries, pointing to the potential effectiveness of policies aimed at increasing schools' social mix in those countries. Table 4 shows rough measures of the so-called "peer effects", *i.e.* the impact of school-average science scores (excluding the student for whom the regression is run) on individual science scores.[20] Estimates are run separately for low, average, and high achievers, where the thresholds are defined according to the country-specific distribution of PISA science scores. The regressions control for student and school-level characteristics (location, resources, size, status and funding).[21] For almost all OECD countries included in the estimation, projected effects are asymmetric: they are relatively weak around the median score of the achievement distribution and stronger at the extremes, with the strongest impact often found on low ability students (exceptions include Italy, Mexico, Poland, Switzerland and the United States). For example, in Belgium, for each improvement of one international standard deviation in the average-school science score, the student performance improves by 39 points at the low end of the skill distribution, while it improves by 12 points around the median, and by 18 points at the high end.[22] Thus, particularly in countries where school socio-economic inequalities are higher, low-skilled/disadvantaged students would benefit more from interacting with high-skilled/socio-economically advantaged students, than the latter would lose from interacting with low-skilled/socio-economically-disadvantaged students. This result has to be taken with care, given the methodological difficulties attached to the estimation of contextual and peer effects, as highlighted above.

Figure 2. **The influence of school environment on students' secondary educational achievement:**[1] **cities *versus* rural areas**

Differences in performance on the PISA science scale associated with the difference between the highest and the lowest quartiles of the country-specific distribution of the school average PISA index of economic, social and cultural status over the entire territory or in rural and urban areas



Notes: Regressions run over rural and urban areas separately where urban areas are defined as communities with more than 100 000 inhabitants. Countries are classified following urban population proportion (urban population over total population where urban population is defined as the mid-year population of areas defined as urban in each country and reported to the United Nations).

Data in parentheses are values of the inter-quartile range of distribution of the school-level average ESCS calculated at the student level for rural and urban areas separately.

France is not included in the analysis because data are not available at the school level.

1. Regression of student science performance on student family socio-economic background (as measured by PISA ESCS), individual control variables (gender, migration status and language spoken at home) and school-level socio-economic background (average PISA ESCS across students in the same school, excluding the individual student for whom the regression is run). Country-by-country least-square regressions are weighted by student sampling probability. Robust standard errors adjusted for clustering at the school level. Regressions for Italy include regional fixed effects.

Source: OECD calculations based on the 2006 *OECD PISA Database*, urban population as a proportion of total population is taken from the *World Development Indicators Database*.

Table 3a. **Estimates of the socio-economic gradient in OECD countries: urban areas**

Impact of parental background on PISA science scores of teenagers

	Australia	Austria	Belgium	Canada	Czech Republic	Denmark	Finland	Germany	Greece	Hungary	Iceland	Ireland	Italy	Japan	Korea
Individual background	28.441***	12.119***	17.042***	24.228***	21.754***	23.131***	32.360***	17.561***	20.025***	8.833***	31.558***	28.670***	9.551***	7.066***	11.088***
	[1.665]	[2.890]	[2.782]	[2.097]	[2.908]	[6.764]	[2.999]	[2.561]	[2.958]	[2.595]	[3.649]	[2.954]	[2.109]	[1.933]	[1.862]
School environment	57.521***	93.391***	90.512***	46.451***	111.080***	15.184	29.522***	100.900***	50.122***	88.498***	53.964***	47.397***	71.247***	127.281***	85.654***
	[5.513]	[8.592]	[7.160]	[5.012]	[12.968]	[22.473]	[10.161]	[10.731]	[8.884]	[8.726]	[13.291]	[6.480]	[6.153]	[12.284]	[9.600]
Female student	–4.422	–7.431	–2.872	–8.017***	–11.948	–9.567	6.319	–6.036	–3.238	–23.717***	2.564	9.343	–12.637***	–1.791	–0.672
	[3.038]	[5.959]	[7.081]	[2.960]	[9.216]	[12.750]	[6.838]	[3.767]	[5.530]	[5.374]	[4.805]	[6.936]	[3.972]	[6.040]	[4.146]
Migration background: first generation	8.063*	–31.385**	4.480	–7.576	–67.319***	–35.577	–48.477	–26.629*	–0.893	–54.978**	–9.393	–27.092	–50.736*	4.801	0.000
	[4.656]	[12.872]	[8.366]	[5.008]	[14.176]	[28.966]	[42.498]	[13.466]	[20.325]	[22.524]	[32.137]	[27.403]	[27.476]	[45.441]	[0.000]
Migration background: second generation	4.144	–38.678***	–41.512***	–25.362***	–32.462	–32.039	–72.964***	–29.951**	–3.442	0.727	9.486	–30.771	–52.812***	54.809*	0.000
	[4.700]	[9.704]	[13.079]	[6.659]	[20.207]	[27.231]	[22.357]	[13.895]	[14.014]	[13.022]	[28.804]	[19.939]	[14.541]	[29.176]	[0.000]
Foreign language spoken at home	–11.106*	–23.846**	–21.288***	7.541	24.251	–79.925***	–16.873	–33.014***	–23.816	–5.845	–43.532**	–13.641	10.946	–112.741***	–9.640
	[6.274]	[11.105]	[5.996]	[6.217]	[35.777]	[27.649]	[19.478]	[9.947]	[16.693]	[19.851]	[21.387]	[20.994]	[16.096]	[20.683]	[24.887]
Number of observations	8 156	1 503	1 360	6 769	914	435	928	937	1 585	1 846	1 168	1 187	4 673	3 701	4 259
R-squared	0.162	0.495	0.488	0.136	0.368	0.250	0.169	0.526	0.256	0.414	0.110	0.241	0.328	0.238	0.193

	Luxembourg	Mexico	Netherlands	New Zealand	Norway	Poland	Portugal	Slovak Republic	Spain	Sweden	Switzerland	Turkey	United Kingdom	United States
Individual background	20.580***	8.533***	10.211***	45.132***	30.172***	37.851***	17.788***	18.863***	21.354***	34.396***	19.609***	11.682***	31.581***	37.688***
	[4.958]	[0.849]	[2.468]	[3.079]	[4.848]	[3.476]	[2.389]	[3.651]	[1.259]	[3.618]	[3.830]	[1.745]	[3.777]	[3.087]
School environment	58.561***	37.590***	108.987***	58.494***	51.235***	49.583***	45.401***	78.862***	27.604***	30.507**	92.375***	72.617***	67.677***	48.251***
	[8.870]	[3.244]	[6.455]	[6.948]	[15.894]	[13.226]	[6.035]	[8.418]	[4.412]	[11.800]	[15.916]	[6.564]	[6.938]	[13.272]
Female student	–2.236	–12.206***	–15.427***	–4.719	7.010	–4.951	–9.372*	–20.595*	–7.107**	–7.902	–8.217	–0.944	–7.070	4.030
	[8.778]	[2.609]	[5.170]	[3.797]	[10.912]	[3.015]	[5.491]	[11.245]	[3.338]	[5.735]	[5.692]	[4.756]	[5.722]	[6.156]
Migration background: first generation	–13.619	–20.133**	–21.527**	–9.797	–17.844	–114.272***	–9.599	–65.725	–17.058*	–0.109	–29.622***	–22.729	–0.571	7.202
	[13.969]	[9.425]	[9.597]	[5.906]	[24.091]	[9.303]	[17.172]	[50.238]	[9.724]	[11.014]	[10.274]	[22.513]	[9.059]	[10.345]
Migration background: second generation	–19.334	–73.430***	–18.627	–13.340**	–5.182	–145.079***	–39.669***	0.000	–53.655***	–44.184**	–46.983***	14.042	–12.270	11.499
	[17.582]	[13.136]	[12.715]	[6.490]	[26.710]	[16.722]	[8.114]	[0.000]	[9.255]	[17.405]	[9.674]	[16.002]	[13.038]	[10.818]
Foreign language spoken at home	–14.699	12.701	–0.322	–24.824***	–14.878	3.771	5.791	–20.471	8.350	–30.721***	–14.443	15.384	–17.339	–13.227
	[14.171]	[31.443]	[13.477]	[7.405]	[19.232]	[18.617]	[9.854]	[22.763]	[21.591]	[11.028]	[10.007]	[16.323]	[13.551]	[8.033]
Number of observations	374	14 739	1 096	2 588	533	1 335	1 021	628	7 563	888	943	2 588	3 165	1 733
R–squared	0.437	0.208	0.566	0.244	0.164	0.240	0.363	0.377	0.205	0.214	0.434	0.386	0.230	0.252

Notes: Regression of student science performance on student PISA index of economic, social and cultural status (ESCS), individual control variables (migration status and language spoken at home), and school-level ESCS (average across students in the same school, excluding the individual student for whom the regression is run). Country-by-country least-square regressions weighted by student sampling probability. Robust standard errors adjusted for clustering at the school level. Regressions for Italy include regional fixed effects. Regressions run over rural and urban areas separately where urban areas are defined as communities with more than 100 000 inhabitants.

Balanced repeated replicate variance estimation, standard errors clustered by school in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: OECD calculations based on the 2006 *OECD PISA Database*.

Table 3b. **Estimates of the socio–economic gradient in OECD countries: rural areas**

Impact of parental background on PISA science scores of teenagers

	Australia	Austria	Belgium	Canada	Czech Republic	Denmark	Finland	Germany	Greece	Hungary	Iceland	Ireland	Italy	Japan	Korea
Individual background	32.228***	9.096***	19.320***	26.070***	24.448***	30.112***	27.359***	16.192***	20.957***	10.624***	25.164***	31.011***	8.904***	12.326***	13.566***
	[2.430]	[2.464]	[1.034]	[2.043]	[1.671]	[1.606]	[1.735]	[1.456]	[1.540]	[2.102]	[2.489]	[1.980]	[1.270]	[4.127]	[4.728]
School environment	43.009***	106.672***	95.346***	33.488***	116.818***	37.221***	9.645	106.580***	59.190***	94.587***	–14.563***	42.903***	81.195***	139.349***	88.648***
	[8.897]	[6.815]	[6.431]	[6.644]	[9.575]	[7.143]	[6.624]	[6.192]	[7.376]	[5.204]	[5.008]	[7.834]	[7.190]	[13.428]	[19.535]
Female student	3.171	–19.668***	–8.102***	–6.695***	–12.223**	–8.547**	–0.513	–12.689***	13.831**	–18.975***	7.904**	–4.259	–12.281***	–14.330*	21.979*
	[3.634]	[4.885]	[2.902]	[2.361]	[5.509]	[3.400]	[2.897]	[2.859]	[5.473]	[3.208]	[3.712]	[3.478]	[3.343]	[7.793]	[11.861]
Migration background: first generation	–16.482**	–46.643***	–21.844***	–11.262	–54.771***	–22.917**	–73.639***	–30.441***	–29.902	–28.299***	–33.470	–4.276	–45.048***	–2.094	15.552*
	[7.013]	[8.248]	[6.459]	[7.475]	[18.278]	[11.106]	[20.176]	[6.166]	[19.391]	[7.208]	[33.879]	[15.605]	[16.845]	[7.562]	[8.708]
Migration background: second generation	–16.785**	–28.359**	–37.933***	–4.679	–25.038	–22.662*	–66.530***	–12.078*	–10.959	3.349	–68.078**	27.743***	–53.381***	–162.198	0.000
	[7.975]	[11.262]	[9.040]	[8.726]	[16.526]	[12.850]	[23.265]	[6.969]	[10.116]	[15.625]	[27.604]	[9.012]	[13.980]	[102.923]	[0.000]
Foreign language spoken at home	–40.405***	–41.874***	–18.488**	–39.314***	–14.180	–32.490***	–5.839	–29.441***	–34.202***	–39.685**	–22.584	–101.134***	–18.997	0.000	0.000
	[12.747]	[10.161]	[7.378]	[8.217]	[17.096]	[12.186]	[22.414]	[6.821]	[11.958]	[15.174]	[23.088]	[17.390]	[14.279]	[0.000]	[0.000]
Number of observations	5 417	3 257	6 571	13 666	4 656	3 128	3 696	3 081	2 929	2 469	2 367	3 165	13 583	1 937	800
R-squared	0.103	0.313	0.369	0.094	0.290	0.157	0.075	0.423	0.253	0.441	0.066	0.140	0.318	0.253	0.139

	Luxembourg	Mexico	Netherlands	New Zealand	Norway	Poland	Portugal	Slovak Republic	Spain	Sweden	Switzerland	Turkey	United Kingdom	United States
Individual background	16.332***	7.306***	12.360***	37.810***	27.867***	36.056***	18.883***	22.942***	25.441***	29.865***	22.391***	10.175***	36.276***	32.018***
	[1.533]	[0.990]	[1.458]	[2.885]	[2.166]	[1.586]	[1.299]	[1.882]	[1.502]	[2.434]	[1.456]	[1.558]	[2.207]	[2.522]
School environment	68.880***	29.156***	127.463***	46.447***	25.702**	1.458	32.005***	66.365***	15.134***	30.507***	71.781***	64.630***	61.676***	45.915***
	[2.795]	[2.802]	[7.822]	[7.761]	[9.979]	[6.918]	[4.200]	[9.098]	[4.024]	[7.921]	[5.437]	[8.571]	[6.958]	[6.219]
Female student	–7.001***	–8.933***	–9.692***	5.761	2.864	0.039	0.010	–7.922**	–4.197**	1.583	–11.439***	5.742	–11.144***	–6.612**
	[2.585]	[2.453]	[2.950]	[5.876]	[3.539]	[2.868]	[2.765]	[3.884]	[2.093]	[3.213]	[2.162]	[4.986]	[3.110]	[2.816]
Migration background: first generation	–23.511***	–57.839***	–26.399***	15.140	–28.409**	90.148*	–61.763***	–11.668	4.020	–27.282**	–40.938***	–15.746	–8.356	8.087
	[4.282]	[11.854]	[9.296]	[12.853]	[14.178]	[51.542]	[9.873]	[14.506]	[16.691]	[11.407]	[4.619]	[27.432]	[10.559]	[9.033]
Migration background: second generation	–22.284***	–76.097***	–32.887***	13.660	–30.344*	76.407***	–63.028***	–30.632	–45.145***	–27.516**	–55.086***	–0.117	–8.052	–10.422
	[4.646]	[7.342]	[8.402]	[11.657]	[15.321]	[2.814]	[12.632]	[32.575]	[9.768]	[12.503]	[6.818]	[12.396]	[13.873]	[13.660]
Foreign language spoken at home	–22.924***	69.331**	–22.114***	–49.295***	–15.870	–0.944	–2.498	–16.796	–8.495	–26.382**	–27.225***	4.995	–1.071	–18.519**
	[4.479]	[30.838]	[7.573]	[17.980]	[12.045]	[17.463]	[10.542]	[26.585]	[15.733]	[10.050]	[5.973]	[12.413]	[13.130]	[8.173]
Number of observations	3 607	14 447	3 582	1 936	3 868	4 019	3 827	3 979	11 276	3 292	10 312	2 196	8 384	3 428
R-squared	0.346	0.184	0.400	0.149	0.076	0.117	0.202	0.271	0.141	0.118	0.295	0.288	0.179	0.182

Notes: Regression of student science performance on student PISA index of economic, social and cultural status (ESCS), individual control variables (migration status and language spoken at home), and school-level ESCS (average across students in the same school, excluding the individual student for whom the regression is run). Country-by-country least-square regressions weighted by student sampling probability. Robust standard errors adjusted for clustering at the school level. Regressions for Italy include regional fixed effects. Regressions run over rural and urban areas separately where urban areas are defined as communities with more than 100 000 inhabitants.

Balanced repeated replicate variance estimation, standard errors clustered by school in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: OECD calculations based on the 2006 *OECD PISA Database*.

Table 4. **Estimates of the socio-economic gradient in OECD countries: asymmetric contextual effects, by science score**

	Austria			Belgium			Canada			Czech Republic			Finland		
Achievement level	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average	High
Parental background	6.797***	0.303	0.233	6.462***	1.381	5.143***	6.496***	2.449***	5.262***	4.376*	3.106***	7.889***	7.316***	2.277***	7.159***
	[1.686]	[1.040]	[1.442]	[1.404]	[0.938]	[0.981]	[1.757]	[0.709]	[1.242]	[2.306]	[0.998]	[1.555]	[1.835]	[0.645]	[1.896]
School science score	0.347***	0.114***	0.244***	0.393***	0.120***	0.183***	0.201***	0.066***	0.127***	0.233***	0.128***	0.284***	0.180***	0.014	0.097
	[0.028]	[0.019]	[0.034]	[0.053]	[0.016]	[0.031]	[0.030]	[0.020]	[0.035]	[0.036]	[0.014]	[0.024]	[0.052]	[0.022]	[0.059]
Index of quality of educational resources	0.334	–1.275	0.068	–1.664	1.175**	–0.215	0.744	0.187	0.765	–3.113*	0.867	2.463	–3.887*	0.215	–3.241*
	[1.480]	[0.909]	[1.617]	[1.785]	[0.574]	[1.066]	[1.160]	[0.512]	[1.182]	[1.832]	[0.881]	[1.581]	[1.962]	[0.955]	[1.857]
Private government dependent school	–6.700	8.685*	17.673	19.323***	–6.893**	5.038	–4.124	0.480	–1.081	3.384	–26.246***	–6.315	–10.909	0.000	13.892
	[11.183]	[4.518]	[11.419]	[5.422]	[2.623]	[4.494]	[10.446]	[3.282]	[4.538]	[25.743]	[4.023]	[8.091]	[12.391]	[4.301]	[13.261]
Public school	–10.446	11.191***	11.688	18.909***	–8.631***	5.647	–10.391	2.382	–3.153	7.670	–26.656***	0.000	0.000	3.574	0.000
	[10.400]	[4.173]	[11.227]	[6.603]	[2.490]	[4.407]	[9.860]	[2.853]	[3.819]	[22.975]	[3.871]	[6.769]	[11.815]	[3.459]	[13.339]
Proportion of certified teachers	–8.199	–1.947	–3.534	–5.183	3.733**	–1.531	–0.894	–6.334*	–0.879	–6.837	–16.684***	–5.268	–0.626	3.282	–2.548
	[5.672]	[4.668]	[4.896]	[4.995]	[1.854]	[4.111]	[3.142]	[3.689]	[7.543]	[6.201]	[4.940]	[6.225]	[6.350]	[3.152]	[3.965]
Ratio of computers for instruction to school size	–0.393	–7.395	5.126	16.211	–2.630	–6.873	–5.233	–1.210	7.708	32.920	–2.359	–16.913**	38.582*	–1.394	27.621
	[8.746]	[6.844]	[12.859]	[13.212]	[4.006]	[8.000]	[6.973]	[4.066]	[9.137]	[20.814]	[3.715]	[8.165]	[20.230]	[11.089]	[20.965]
Average student learning time at school	0.144	–0.531	1.489**	–0.914	0.314	0.912	1.318**	–0.129	0.644	0.969	0.519	1.594*	–0.217	0.095	0.021
	[0.884]	[0.557]	[0.744]	[1.012]	[0.310]	[0.666]	[0.541]	[0.269]	[0.470]	[0.754]	[0.445]	[0.824]	[0.840]	[0.477]	[0.988]
Average class size	0.467*	0.126	–0.640***	0.106	–0.024	–0.067	0.259	–0.051	0.232	0.938***	–0.070	–0.402	0.368**	–0.096	–0.060
	[0.272]	[0.162]	[0.221]	[0.245]	[0.156]	[0.265]	[0.251]	[0.127]	[0.196]	[0.289]	[0.142]	[0.261]	[0.157]	[0.089]	[0.191]
Teacher shortage	–0.659	–0.186	3.717**	–3.673**	1.026**	0.770	1.663	–0.075	1.365	–2.971	–0.764	–2.612	2.482	3.548***	–1.381
	[2.020]	[0.980]	[1.736]	[1.594]	[0.497]	[1.155]	[1.323]	[0.579]	[1.007]	[2.133]	[0.943]	[1.702]	[1.856]	[0.979]	[1.977]
Female student	–7.003***	0.519	–7.857***	0.564	–1.944	–9.934***	4.054*	–1.625	–6.785***	–7.140**	–0.069	–8.681***	8.771***	0.288	–6.442***
	[2.640]	[1.356]	[2.228]	[2.904]	[1.174]	[2.014]	[2.363]	[1.084]	[2.275]	[2.877]	[1.553]	[2.170]	[2.325]	[1.032]	[2.327]
Migration background: first generation	–23.737***	–6.844	4.445	6.338	–0.680	–9.145	–5.671	–1.528	–0.873	–21.885*	13.954**	5.128	–22.531	–4.123	–14.426***
	[8.498]	[5.295]	[8.338]	[5.226]	[3.138]	[5.522]	[4.310]	[2.012]	[4.225]	[13.016]	[5.414]	[11.233]	[18.339]	[9.024]	[3.418]
Migration background: second generation	–32.753***	–2.817	–9.855	–11.128**	–1.403	2.657	–11.820**	2.210	–3.463	–14.196	–13.683	–30.691***	–24.372	–4.900	28.322
	[6.786]	[4.382]	[6.068]	[5.557]	[3.125]	[5.983]	[5.190]	[2.773]	[8.059]	[15.929]	[9.069]	[8.473]	[14.999]	[10.672]	[20.204]
Foreign language spoken at home	–2.558	–4.951	–15.219*	–22.243***	–2.862	–12.800**	–2.576	–0.429	7.446	–15.441	10.564	14.657	–13.015	5.047	–25.878**
	[6.456]	[4.126]	[8.131]	[5.360]	[3.110]	[6.374]	[4.584]	[2.766]	[6.218]	[17.577]	[7.553]	[8.938]	[17.492]	[11.022]	[9.895]
Number of observations	1 237	1 466	1 479	1 792	2 158	2 296	5 291	4 807	4 440	1 357	1 492	2 263	1 413	1 439	1 432
R-squared	0.356	0.095	0.096	0.269	0.098	0.101	0.076	0.024	0.036	0.182	0.085	0.208	0.079	0.017	0.038

Table 4. **Estimates of the socio-economic gradient in OECD countries: asymmetric contextual effects, by science score** *(cont.)*

	Germany			Greece			Hungary			Iceland			Ireland		
Achievement level	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average	High
Parental background	4.060*	2.846***	6.756***	5.711***	1.810*	7.886***	3.657**	–0.740	2.042	4.612***	1.267	6.600***	8.661***	1.457	7.802***
	[2.110]	[0.886]	[1.597]	[2.056]	[0.952]	[1.327]	[1.633]	[0.733]	[1.579]	[1.567]	[0.873]	[1.590]	[2.149]	[0.994]	[1.573]
School science score	0.332***	0.080***	0.270***	0.375***	0.084***	0.255***	0.346***	0.100***	0.287***	0.162***	0.038	0.093*	0.172***	0.062**	0.023
	[0.040]	[0.018]	[0.029]	[0.056]	[0.024]	[0.042]	[0.034]	[0.021]	[0.039]	[0.061]	[0.030]	[0.053]	[0.050]	[0.029]	[0.047]
Index of quality of educational resources	1.459	0.996	–1.998	–4.048	–0.621	–1.696	1.652	–0.852	2.566*	1.134	–2.395**	0.489	1.478	1.291*	1.688
	[1.948]	[0.888]	[1.299]	[2.525]	[0.971]	[1.423]	[1.657]	[1.087]	[1.500]	[1.949]	[1.124]	[1.850]	[2.155]	[0.719]	[1.629]
Private government dependent school	–13.448	8.956**	6.318	0.000	0.000	0.000	–9.879	0.285	14.741**	1.755	0.000	–14.044	8.061	1.222	–6.869
	[9.932]	[4.390]	[11.276]	[0.000]	[0.000]	[0.000]	[13.221]	[5.318]	[5.740]	[53.114]	[14.984]	[19.826]	[11.874]	[4.499]	[15.328]
Public school	–12.035*	0.118	1.193	11.128	5.078	6.214	–11.906	0.915	10.943*	10.444	13.174	0.000	4.564	–2.758	–12.407
	[6.846]	[3.299]	[7.693]	[8.609]	[3.169]	[5.002]	[13.517]	[5.335]	[6.292]	[49.170]	[13.142]	[12.954]	[12.193]	[4.451]	[15.890]
Proportion of certified teachers	2.580	–1.858	–5.069	–8.726	–10.898	–8.497	4.375	–3.311	11.302	–7.620	–8.957	–5.706	–8.941	5.689	1.874
	[6.615]	[3.177]	[6.751]	[15.819]	[7.059]	[5.253]	[6.325]	[6.842]	[7.821]	[15.636]	[9.072]	[21.884]	[7.057]	[4.911]	[25.664]
Ratio of computers for instruction to school size	–13.319	6.038	31.747	9.798	5.233	53.709*	–2.691	–3.421	–25.971***	–36.024	–7.117	11.212	–30.468	7.570	9.564
	[25.500]	[12.255]	[27.528]	[22.932]	[14.106]	[27.214]	[8.332]	[6.144]	[6.538]	[29.603]	[12.768]	[21.409]	[26.246]	[12.366]	[26.778]
Average student learning time at school	1.165	0.686	1.619*	0.351	0.084	0.890	0.937	1.503**	0.526	3.945***	–0.107	0.346	–0.070	–1.451**	–0.556
	[0.807]	[0.446]	[0.968]	[1.363]	[0.611]	[1.304]	[0.906]	[0.678]	[0.995]	[1.251]	[0.728]	[1.419]	[1.350]	[0.556]	[1.066]
Average class size	0.735*	0.049	–0.388	0.019	–0.038	0.003	0.587**	–0.109	0.069	–0.396*	0.037	–0.121	0.233	0.305	0.026
	[0.442]	[0.195]	[0.424]	[0.106]	[0.055]	[0.083]	[0.225]	[0.098]	[0.157]	[0.226]	[0.105]	[0.170]	[0.467]	[0.218]	[0.378]
Teacher shortage	–0.144	0.855	–0.659	–3.848**	–1.715**	1.511	4.738**	–0.782	–6.013***	–1.910	–1.767*	3.251*	–1.871	0.734	–1.494
	[1.937]	[0.807]	[1.301]	[1.864]	[0.684]	[1.070]	[1.965]	[1.212]	[2.105]	[2.052]	[1.001]	[1.756]	[2.293]	[0.831]	[1.720]
Female student	–4.596*	–0.439	–8.452***	–0.383	1.264	–9.159***	–6.570**	–2.470**	–13.472***	9.083***	0.888	–5.359**	3.538	–2.102	–5.831**
	[2.330]	[1.438]	[2.143]	[3.260]	[1.405]	[3.063]	[2.741]	[1.158]	[2.272]	[3.354]	[1.377]	[2.562]	[2.475]	[1.425]	[2.534]
Migration background: first generation	–4.493	–8.156*	–13.854	–4.276	–7.627	15.794	–9.637	–19.484***	–39.364***	–29.433	9.875	–21.106*	–11.081	–11.808**	–7.753
	[5.582]	[4.849]	[8.787]	[13.601]	[7.883]	[15.170]	[24.192]	[4.055]	[7.322]	[23.877]	[10.517]	[11.593]	[10.604]	[5.391]	[9.064]
Migration background: second generation	–10.926	–5.480	–2.836	5.628	0.689	17.374*	–11.635	2.596	3.252	–0.278	–11.261	14.218	4.383	6.789*	7.903
	[7.137]	[3.512]	[9.684]	[7.766]	[3.139]	[9.126]	[19.652]	[6.144]	[10.884]	[16.809]	[8.458]	[33.367]	[7.316]	[3.990]	[7.667]
Foreign language spoken at home	–8.660*	0.320	–3.685	–16.836	0.964	–9.456	–12.780	9.865	19.475	–25.645*	–5.727	–8.959	–41.472***	–11.683*	–29.448**
	[5.195]	[2.884]	[7.758]	[10.652]	[5.755]	[10.886]	[12.634]	[8.208]	[12.575]	[13.655]	[7.102]	[16.114]	[12.250]	[6.866]	[11.187]
Number of observations	933	1 131	1 206	1 142	1 131	1 194	1 169	1 390	1 455	1 045	1 119	1 130	1 122	1 183	1 187
R-squared	0.313	0.101	0.132	0.283	0.040	0.108	0.246	0.084	0.205	0.072	0.020	0.029	0.097	0.036	0.040

Table 4. **Estimates of the socio-economic gradient in OECD countries: asymmetric contextual effects, by science score** *(cont.)*

	Italy			Japan			Korea			Luxembourg			Mexico		
Achievement level	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average	High
Parental background	2.404**	0.047	4.422***	1.179	0.274	3.846**	–1.124	–0.094	4.365***	4.254***	1.665**	4.765***	–0.048	1.192**	3.267***
	[1.180]	[0.588]	[1.129]	[2.338]	[0.908]	[1.792]	[1.803]	[0.889]	[1.198]	[1.589]	[0.686]	[1.206]	[1.310]	[0.530]	[0.810]
School science score	0.288***	0.106***	0.321***	0.365***	0.098***	0.295***	0.369***	0.097***	0.243***	0.290***	0.038	0.274***	0.212***	0.089***	0.382***
	[0.025]	[0.012]	[0.016]	[0.037]	[0.013]	[0.031]	[0.048]	[0.018]	[0.033]	[0.051]	[0.026]	[0.045]	[0.037]	[0.019]	[0.033]
Index of quality of educational resources	–0.931	1.038**	–0.279	0.745	–0.501	–0.712	–2.576	0.122	1.289	0.420	2.867***	0.186	0.904	1.018**	0.350
	[1.137]	[0.433]	[0.908]	[1.671]	[0.643]	[1.114]	[1.813]	[0.746]	[1.151]	[2.021]	[0.957]	[1.594]	[0.892]	[0.493]	[0.977]
Private government dependent school	24.891**	–6.122	11.068**	–1.159	9.126***	–8.422	6.306	–2.210	–3.054	–4.497	3.367	17.602	0.000	0.000	0.000
	[10.426]	[3.792]	[5.144]	[6.431]	[2.269]	[5.860]	[4.342]	[2.131]	[3.517]	[6.048]	[3.757]	[16.999]	[0.000]	[0.000]	[0.000]
Public school	12.379	–5.103	0.650	3.630	2.934*	–0.332	3.667	0.160	–2.120	0.000	0.000	0.000	4.976	2.693*	4.187
	[9.308]	[3.871]	[4.440]	[4.368]	[1.597]	[2.511]	[3.759]	[1.940]	[3.106]	[5.454]	[3.006]	[17.901]	[5.788]	[1.532]	[3.182]
Proportion of certified teachers	–3.065	–1.360	–10.999***	–21.116	–9.716**	3.685	–15.367***	–2.445	0.492	–6.998	6.680	–14.209	0.828	–0.644	1.448
	[3.446]	[2.256]	[2.878]	[19.013]	[4.541]	[7.525]	[4.724]	[1.893]	[6.330]	[14.451]	[6.152]	[12.155]	[1.973]	[1.229]	[2.141]
Ratio of computers for instruction to school size	–14.358	–5.496	–12.334*	5.468	0.423	–5.992	15.953*	–2.813	1.847	–2.086	–7.290	–18.744**	3.019	1.526	–11.668
	[9.294]	[5.147]	[6.282]	[6.247]	[3.775]	[11.063]	[9.212]	[4.392]	[13.484]	[10.792]	[7.031]	[9.337]	[8.909]	[6.937]	[7.500]
Average student learning time at school	0.389	0.297	0.526	0.310	0.239	–0.886	1.111	–0.174	–1.342*	–0.427	2.598**	–2.677	0.135	–0.026	–0.177
	[0.621]	[0.264]	[0.490]	[0.903]	[0.328]	[0.846]	[1.099]	[0.422]	[0.766]	[2.704]	[1.139]	[1.937]	[0.465]	[0.424]	[0.711]
Average class size	–0.040	–0.168***	0.028	0.535***	0.022	–0.074	–0.151	–0.267	0.259	–2.907***	0.175	0.877	0.038	–0.037	–0.111
	[0.135]	[0.042]	[0.101]	[0.183]	[0.110]	[0.207]	[0.473]	[0.216]	[0.297]	[0.825]	[0.341]	[0.606]	[0.068]	[0.046]	[0.121]
Teacher shortage	–0.116	0.288	–2.127**	1.477	1.090	–1.383	–0.799	0.313	0.360	–5.883*	4.797***	2.213	–1.158	–0.052	0.449
	[1.096]	[0.519]	[0.892]	[1.503]	[0.892]	[1.665]	[2.029]	[0.676]	[1.125]	[3.165]	[1.556]	[3.328]	[0.921]	[0.526]	[1.065]
Female student	3.347*	–3.136***	–9.934***	0.410	–1.231	–5.780***	6.539**	–0.467	0.021	5.191*	1.914	–8.867***	–2.515	–0.314	–6.950**
	[2.000]	[0.873]	[1.568]	[2.742]	[1.143]	[1.678]	[2.850]	[1.158]	[1.801]	[2.986]	[1.447]	[2.146]	[1.921]	[1.222]	[2.833]
Migration background: first generation	–42.970**	8.673*	–3.231	–53.645**	3.550	68.830***	0.000	19.585***	0.000	–6.551	–2.794	–8.039*	–4.622	–9.482**	–11.845**
	[18.051]	[5.134]	[21.825]	[20.542]	[3.270]	[3.549]	[0.000]	[2.104]	[0.000]	[4.805]	[2.061]	[4.114]	[6.956]	[4.281]	[5.302]
Migration background: second generation	–23.389**	–3.063	–37.823***	–12.910	5.591	–27.066***	0.000	0.000	0.000	–17.189***	–6.163**	0.940	–26.899***	–17.793**	–24.379***
	[10.812]	[3.887]	[12.679]	[51.704]	[16.753]	[3.457]	[0.000]	[0.000]	[0.000]	[5.369]	[2.691]	[5.326]	[7.278]	[7.035]	[6.001]
Foreign language spoken at home	4.147	–5.328	30.426*	–56.487***	–4.637	20.615	51.008***	0.000	–50.012***	–3.694	–1.988	1.776	14.392**	7.022	62.916***
	[12.191]	[4.329]	[16.399]	[11.619]	[2.881]	[14.979]	[10.476]	[0.000]	[2.162]	[5.058]	[2.450]	[5.405]	[6.244]	[5.577]	[21.174]
Number of observations	3 560	4 664	6 196	1 685	1 856	1 944	1 615	1 636	1 670	1 162	1 348	1 447	3 364	4 804	4 873
R-squared	0.161	0.066	0.145	0.169	0.062	0.133	0.184	0.040	0.089	0.123	0.064	0.097	0.099	0.073	0.218

Table 4. **Estimates of the socio-economic gradient in OECD countries: asymmetric contextual effects, by science score** *(cont.)*

	Netherlands			New Zealand			Norway			Poland			Portugal		
Achievement level	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average	High
Parental background	3.613**	0.549	6.786***	12.147***	4.175***	15.374***	5.621***	2.146**	8.976***	11.696***	2.920***	9.725***	2.829**	2.030***	6.420***
	[1.577]	[0.855]	[1.229]	[2.576]	[1.117]	[1.868]	[1.725]	[0.898]	[1.953]	[1.352]	[0.755]	[1.283]	[1.345]	[0.592]	[0.975]
School science score	0.291***	0.177***	0.278***	0.130**	–0.010	0.117**	0.238***	0.108***	0.095*	0.175***	0.074***	0.215***	0.258***	0.087***	0.075
	[0.042]	[0.018]	[0.024]	[0.055]	[0.025]	[0.046]	[0.045]	[0.021]	[0.053]	[0.047]	[0.021]	[0.033]	[0.032]	[0.020]	[0.048]
Index of quality of educational resources	2.192	0.750	–2.064**	–2.653	0.844	0.424	6.242**	1.002	–1.385	1.608	–1.121	0.801	–2.347	–0.015	0.495
	[1.711]	[0.924]	[0.852]	[1.894]	[0.991]	[1.569]	[2.502]	[1.063]	[2.693]	[1.270]	[0.688]	[1.197]	[2.292]	[0.783]	[1.518]
Private government dependent school	–4.263	0.193	0.000	0.000	0.000	0.000	–6.050	–2.524	0.000	–37.449***	2.668	–1.332	–14.063	2.402	–10.130
	[4.233]	[1.312]	[1.871]	[0.000]	[0.000]	[0.000]	[8.520]	[3.810]	[6.086]	[12.735]	[6.594]	[9.745]	[17.261]	[8.451]	[6.250]
Public school	0.000	0.000	–0.374	–0.085	–3.045	–1.708	0.000	0.000	–2.403	–17.177***	0.298	0.519	–19.379	–0.671	–4.981
	[3.597]	[0.534]	[1.310]	[13.679]	[3.579]	[5.289]	[6.838]	[3.085]	[5.404]	[5.857]	[4.831]	[9.969]	[17.464]	[8.031]	[5.714]
Proportion of certified teachers	4.396	4.933	–7.334	–13.378	–2.630	–8.772	–18.928***	2.702	6.578*	–2.504	6.469	15.713***	7.419	3.248	–14.820
	[7.647]	[4.631]	[5.297]	[8.350]	[5.400]	[7.780]	[6.796]	[2.547]	[3.586]	[6.996]	[4.603]	[4.976]	[7.190]	[2.641]	[9.568]
Ratio of computers for instruction to school size	–18.114	9.995	–4.136	6.971	13.922	–0.178	–1.951	–2.920	2.819	10.217	–0.958	22.220	12.725	17.325	–11.133
	[17.396]	[9.673]	[18.108]	[26.876]	[10.386]	[17.725]	[19.849]	[7.979]	[18.354]	[22.513]	[9.980]	[22.127]	[65.991]	[14.911]	[32.648]
Average student learning time at school	3.760***	0.715	–0.309	2.906**	0.234	–0.832	1.754	0.271	–1.489	0.341	0.494	–1.205	0.214	0.656	2.669***
	[0.976]	[0.610]	[0.732]	[1.191]	[0.874]	[1.436]	[1.199]	[0.500]	[1.088]	[1.058]	[0.505]	[0.880]	[1.222]	[0.665]	[0.941]
Average class size	0.206	–0.381**	0.382	0.733*	–0.157	0.299	–0.216	0.031	–0.238	–0.026	–0.219	–0.078	0.527*	–0.008	0.240
	[0.188]	[0.168]	[0.274]	[0.415]	[0.267]	[0.521]	[0.196]	[0.084]	[0.187]	[0.370]	[0.210]	[0.362]	[0.315]	[0.150]	[0.249]
Teacher shortage	0.646	0.008	–1.294	2.249	1.320	–2.143	4.489**	1.829**	–0.270	0.875	1.165	–3.656*	2.351	0.597	–1.551
	[1.640]	[0.818]	[1.235]	[2.343]	[0.952]	[1.360]	[2.253]	[0.906]	[1.962]	[2.241]	[0.894]	[1.888]	[2.417]	[1.511]	[2.613]
Female student	–4.324	–3.981***	–9.180***	5.933*	–1.042	–6.490**	11.832***	–0.486	–2.851	3.907*	–0.777	–7.849***	3.088	0.001	–2.353
	[3.233]	[1.472]	[2.273]	[3.138]	[1.921]	[3.056]	[3.923]	[1.460]	[3.052]	[2.003]	[1.037]	[2.100]	[2.580]	[1.397]	[2.124]
Migration background: first generation	–4.446	–10.578***	–10.845***	0.812	4.222	–6.775	–21.142**	4.013	–17.134	62.593***	–30.396***	42.775	–14.009	–3.434	–3.180
	[5.476]	[3.215]	[3.578]	[5.566]	[3.726]	[5.534]	[8.785]	[6.347]	[10.550]	[3.514]	[2.353]	[32.332]	[9.230]	[4.905]	[7.008]
Migration background: second generation	–9.644	–9.016*	–1.801	–5.477	–2.146	–3.157	–9.843	–0.904	2.779	–44.766**	0.000	–19.950***	–13.848**	2.072	1.266
	[10.584]	[4.837]	[6.197]	[7.605]	[3.227]	[4.818]	[12.980]	[6.138]	[15.232]	[19.136]	[0.000]	[2.235]	[6.572]	[4.052]	[14.346]
Foreign language spoken at home	–14.035	–4.704	–8.663*	–21.984**	–4.920	11.839	–3.649	–1.791	0.603	32.218***	–1.760	11.379	5.111	–6.524	–2.383
	[10.055]	[4.810]	[5.195]	[9.410]	[3.700]	[8.392]	[11.706]	[5.586]	[13.223]	[6.524]	[9.327]	[17.659]	[7.216]	[4.871]	[12.853]
Number of observations	1 074	1 362	1 576	1 090	1 254	1 315	1 220	1 328	1 320	1 585	1 703	1 838	1 267	1 426	1 489
R-squared	0.291	0.165	0.119	0.125	0.025	0.087	0.102	0.029	0.036	0.075	0.031	0.095	0.139	0.074	0.094

Notes: Regression of student science performance on student PISA index of economic, social and cultural status (ESCS), school-level (weighted) average performance (average across students in the same school, excluding the individual student for whom the regression is run), plus individual control variables (gender, migration status and language spoken at home) and school-level control variables (school location, school size and school size squared, index of quality of educational resources, index of teacher shortage, proportion of certified teachers, ratio of computers for instruction to school size, average class size, average student learning time at school, school type: private independent, private government dependent or public). Regressions are run separately for each tertile of the student science score distribution, where the distribution is country specific. Tertiles are ordered as low, average and high where low refers to the first tertile and high to the last. Regressions for Italy include regional fixed effects.

Country-by-country least-square regressions weighted by student sampling probability. Robust standard errors adjusted for clustering at the school level. All regressions include a constant. Balanced repeated replicate variance estimation, standard errors clustered by school in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: OECD calculations based on the 2006 *OECD PISA Database*.

Table 4. **Estimates of the socio-economic gradient in OECD countries: asymmetric contextual effects, by science score** *(cont.)*

	Slovak Republic			Sweden			Switzerland			United Kingdom			United States		
Achievement level	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average	High
Parental background	6.090***	1.668*	4.301***	5.506**	3.948***	7.925***	6.039***	2.207***	5.902***	3.974**	3.920***	7.452***	3.647	3.699***	8.069***
	[2.178]	[0.887]	[1.432]	[2.111]	[1.076]	[1.675]	[1.583]	[0.695]	[1.176]	[1.900]	[0.953]	[1.966]	[2.245]	[1.296]	[1.778]
School science score	0.374***	0.089***	0.229***	0.246***	0.033	0.089**	0.240***	0.107***	0.265***	0.280***	0.053***	0.205***	0.085**	0.039	0.241***
	[0.041]	[0.016]	[0.026]	[0.054]	[0.028]	[0.043]	[0.053]	[0.014]	[0.029]	[0.075]	[0.019]	[0.024]	[0.042]	[0.027]	[0.041]
Index of quality of educational resources	1.090	0.903	0.610	3.052**	0.145	1.360	0.101	0.379	1.678	–0.038	0.553	–1.197	–0.666	–0.374	0.046
	[1.504]	[0.801]	[1.477]	[1.518]	[0.847]	[1.816]	[1.430]	[0.481]	[1.025]	[1.856]	[0.797]	[1.029]	[1.526]	[0.852]	[1.648]
Private government dependent school	–27.500***	3.772	7.799	0.000	–3.804	6.307	–33.845*	2.339	35.490***	34.154***	–3.156	–0.351	–33.411***	7.623	17.933**
	[5.721]	[3.954]	[5.595]	[6.131]	[4.467]	[7.484]	[20.297]	[5.415]	[4.578]	[8.336]	[5.347]	[5.914]	[8.077]	[4.890]	[8.673]
Public school	–9.767***	2.007	4.958	5.406	0.000	0.000	9.561	5.730	10.053**	17.244**	–1.086	–1.535	–12.123*	1.170	8.818
	[2.571]	[1.988]	[3.095]	[5.603]	[4.039]	[6.547]	[9.372]	[4.489]	[4.387]	[8.496]	[3.882]	[3.935]	[6.982]	[4.408]	[6.583]
Proportion of certified teachers	–6.087	–0.258	11.425	39.482***	–13.651*	–0.112	11.313*	–2.748	3.022	2.028	–5.022	8.465	–6.884	7.170	–20.731**
	[8.511]	[4.149]	[7.449]	[14.776]	[8.129]	[13.103]	[5.858]	[1.957]	[3.886]	[14.766]	[3.694]	[9.036]	[7.408]	[6.426]	[9.659]
Ratio of computers for instruction to school size	41.492	0.634	–40.386	11.167	10.880	–6.613	6.695	4.605	–12.825	–7.361	3.886	–5.591	–9.036	–0.668	1.718
	[49.036]	[19.475]	[32.276]	[17.251]	[12.872]	[13.206]	[7.004]	[4.035]	[8.612]	[12.932]	[7.089]	[11.093]	[12.423]	[5.816]	[9.280]
Average student learning time at school	–0.658	–0.189	–0.723	4.764***	0.642	0.536	1.272	0.152	–0.987	2.228**	0.410	–0.373	2.193*	0.967*	–2.108**
	[0.828]	[0.364]	[0.584]	[1.745]	[0.882]	[1.384]	[0.965]	[0.334]	[0.764]	[1.117]	[0.574]	[0.948]	[1.147]	[0.576]	[1.014]
Average class size	0.119	0.179*	0.086	–0.060	0.151	0.027	0.558	0.273	–0.170	–0.183	–0.250	–0.571	–0.522*	–0.026	–0.132
	[0.270]	[0.095]	[0.239]	[0.346]	[0.184]	[0.294]	[0.368]	[0.184]	[0.318]	[0.436]	[0.223]	[0.461]	[0.271]	[0.167]	[0.379]
Teacher shortage	–1.184	–0.690	–1.987	2.566	–0.315	–0.430	1.107	–0.627	0.404	–4.292***	–0.926	–0.726	0.648	–1.447	–0.021
	[1.581]	[0.562]	[1.605]	[2.202]	[1.226]	[1.877]	[1.377]	[0.572]	[1.093]	[1.556]	[0.743]	[1.292]	[1.874]	[0.871]	[1.336]
Female student	–0.225	–1.786	–11.951***	4.930	1.164	–2.034	–1.735	–1.705	–6.790***	2.955	–0.877	–6.577**	10.416***	–0.282	–8.040**
	[2.641]	[1.275]	[1.909]	[3.545]	[2.037]	[2.733]	[2.367]	[1.299]	[1.883]	[2.865]	[1.330]	[2.545]	[2.955]	[1.632]	[3.257]
Migration background: first generation	5.584	–8.152	–17.183***	–6.437	–2.163	6.167	–10.708**	–4.253**	–8.705**	21.510***	–7.164**	–10.954*	2.078	–0.718	6.252
	[20.620]	[7.762]	[5.529]	[8.043]	[3.972]	[7.437]	[4.331]	[1.699]	[3.821]	[5.086]	[3.564]	[6.119]	[5.718]	[3.653]	[6.271]
Migration background: second generation	–61.197***	22.126**	–20.927	–20.631***	–9.787*	13.061	–24.075***	–3.962	–7.005*	–7.291	–7.734	–1.565	–11.620	2.484	8.127
	[11.797]	[8.739]	[21.632]	[7.474]	[5.340]	[12.177]	[5.561]	[2.673]	[3.782]	[8.798]	[6.643]	[7.717]	[7.219]	[4.131]	[11.276]
Foreign language spoken at home	–11.633	–2.628	13.226	–7.030	3.375	–17.542**	–13.089**	–0.509	–2.326	1.904	8.340	–13.022	0.165	–5.429	–17.666**
	[27.742]	[9.627]	[49.677]	[7.350]	[4.089]	[6.726]	[5.442]	[2.322]	[5.519]	[7.879]	[5.918]	[8.252]	[6.976]	[3.720]	[8.508]
Number of observations	1 401	1 503	1 544	1 135	1 202	1 232	2 912	3 142	2 899	3 028	3 380	3 410	1 244	1 397	1 389
R-squared	0.208	0.049	0.138	0.132	0.034	0.038	0.200	0.067	0.158	0.108	0.039	0.091	0.079	0.041	0.089

Notes: Regression of student science performance on student PISA index of economic, social and cultural status (ESCS), school-level (weighted) average performance (average across students in the same school, excluding the individual student for whom the regression is run), plus individual control variables (gender, migration status and language spoken at home) and school-level control variables (school location, school size and school size squared, index of quality of educational resources, index of teacher shortage, proportion of certified teachers, ratio of computers for instruction to school size, average class size, average student learning time at school, school type: private independent, private government dependent or public). Regressions are run separately for each tertile of the student science score distribution, where the distribution is country specific. Tertiles are ordered as low, average, high where low refers to the first tertile and high to the last. Regressions for Italy include regional fixed effects.

Country-by-country least-square regressions weighted by student sampling probability. Robust standard errors adjusted for clustering at the school level. All regressions include a constant. Balanced repeated replicate variance estimation, standard errors clustered by school in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: OECD calculations based on the 2006 *OECD PISA Database*.

Social gains from reallocating students across schools and/or classes are realised if there is no adverse effect of social heterogeneity *per se* on educational achievement. Students may be influenced, not only by the mean level of peer quality, but also by the diversity of their peers. Regression results presented in Table 5 suggest that in most OECD countries there is no adverse effect of social heterogeneity on student performance. The effect of social heterogeneity on educational achievement is tested by including the standard deviation of the student socio-economic background in each school. The regressions also control for student and school-level characteristics (socio-economic intake, location, resources, size, ownership and funding). The impact of social heterogeneity is statistically insignificant for 26 out of 29 countries, the exceptions being Italy, the Czech Republic, and Finland, where a negative impact is found. These results are only suggestive, given that, due to data limitations, the data used is school-level as opposed to class-level, which would be needed to properly analyse peer effects. Taken at face value, the results reported in Tables 4 and 5 suggest that in some countries increasing school mix could achieve equity and efficiency goals, particularly in highly socially-segregated countries.

3. The impact of policies on equity in education achievement across OECD countries

3.1. Motivation

As one of the major mechanisms through which economic advantages and disadvantages are transmitted, education plays a central role in intergenerational social mobility. This makes it, by the same token, an accessible policy instrument to increase intergenerational social mobility. Indeed, while there is little scope nor rationale for attenuating inequalities arising from the transmission of inheritable factors, inequalities in the distribution of learning opportunities might signal economic inefficiencies potentially amenable to policy intervention. Cross-country empirical analysis allows examining to what extent different institutions would moderate or reinforce the relationship between socio-economic background and student performance.

Research in this field has generally focused on the role of educational policies and institutions. Institutional features such as early intervention, education, welfare and redistribution policies are likely to have an impact on equity in student achievement in OECD countries. This section describes the empirical approach undertaken in trying to identify the effects of policies at the cross-country level, and presents and discusses the relevant results, in the light of those already provided in the literature.

3.2. Empirical approach

3.2.1. The model

The baseline empirical approach for analysing the impact of policies on equity in educational achievement in this study is based on two cross-country variants of equation (2):

$$Y_{isc} = \alpha_1 + \beta_w \cdot F_{isc} + \beta_b \cdot \overline{F_{sc}} + \gamma_c \cdot X_{isc} + \chi_c \cdot Z_{sc} + \psi \cdot W_{c\cdot} + \varepsilon_{isc} \quad (4a)$$

$$Y_{isc} = \alpha_1 + \beta_w \cdot F_{isc} + \beta_b \cdot \overline{F_{sc}} + \gamma_c \cdot X_{isc} + \chi_c \cdot Z_{sc} + \theta \cdot C_{c\cdot} + \varepsilon_{isc} \quad (4b)$$

where X_{isc} denotes student characteristics, Z_{sc} denotes school characteristics, W_c denotes country-level variables, and C_c denotes country fixed effects. In these equations, all school and student-level characteristics display country-specific coefficients. Equations (4a) and (4b) describe country-specific models, in which only the impact of the variables F_{isc}, $\overline{F_{sc}}$

Table 5. **Estimates of the socio-economic gradient in OECD countries: the impact of heterogeneity in the school environment**

	Austria	Belgium	Canada	Czech Republic	Finland	Germany	Greece	Hungary	Iceland	Ireland	Italy	Japan	Korea
Individual background	7.696***	17.404***	25.581***	22.923***	28.520***	15.333***	18.139***	8.202***	27.739***	30.226***	9.354***	7.097***	10.383***
	[1.884]	[1.080]	[1.740]	[1.620]	[1.684]	[1.371]	[1.646]	[1.589]	[1.989]	[1.854]	[1.327]	[1.983]	[1.774]
School environment	68.751***	58.553***	29.425***	75.675***	4.067	70.916***	31.300***	73.048***	12.700*	37.553***	79.572***	98.088***	59.508***
	[8.465]	[7.040]	[5.988]	[9.200]	[6.783]	[7.929]	[7.120]	[5.002]	[6.509]	[6.532]	[4.751]	[11.711]	[9.440]
School-level ESCS standard deviation	11.512	30.520	–13.239	–70.335**	–44.579**	–5.041	8.996	14.363	–5.512	6.143	–94.208***	–39.736	6.505
	[26.674]	[19.396]	[18.871]	[29.087]	[18.374]	[16.025]	[22.138]	[15.348]	[17.724]	[21.362]	[19.720]	[34.285]	[30.606]
Index of quality of educational resources	1.555	1.501	–0.095	–2.207	–3.150	2.922	0.361	–0.522	–1.776	4.137	5.229**	1.120	4.061
	[3.412]	[3.264]	[2.088]	[4.059]	[2.413]	[2.742]	[3.781]	[2.564]	[2.035]	[3.051]	[2.399]	[2.760]	[3.379]
Private government dependent school	–78.602***	–5.493	6.017	96.429**	0.715	45.064**	0.000	16.142	123.954***	30.314***	50.575**	–70.706***	0.760
	[21.680]	[9.507]	[11.610]	[46.218]	[10.901]	[20.661]	[0.000]	[17.194]	[39.970]	[8.882]	[19.639]	[8.531]	[8.241]
Public school	–78.954***	–17.113*	–12.864	126.164***	0.000	40.745***	27.990**	16.100	167.977***	18.520*	46.852***	51.266***	5.199
	[22.173]	[9.168]	[9.135]	[47.755]	[6.931]	[14.130]	[11.433]	[16.419]	[33.815]	[9.472]	[12.265]	[6.649]	[6.711]
Proportion of certified teachers	–0.956	12.971	–5.842	–1.980	2.292	3.747	–21.975	38.816**	47.234**	26.410*	11.876	–46.650***	–34.358***
	[16.197]	[11.912]	[8.917]	[20.162]	[7.869]	[13.100]	[25.667]	[16.148]	[22.472]	[14.293]	[12.802]	[16.177]	[10.034]
Ratio of computers for instruction to school size	27.469	42.375**	20.087	71.926*	12.004	–13.518	47.780	41.407**	–13.012	29.473	22.236	21.478	17.023
	[19.052]	[18.628]	[13.261]	[42.964]	[20.975]	[55.118]	[36.276]	[19.693]	[27.670]	[51.566]	[21.593]	[17.190]	[24.061]
Average student learning time at school	6.960***	7.181***	1.782*	5.380***	4.757***	7.229***	16.665***	10.367***	4.556***	4.434**	7.563***	8.645***	11.889***
	[2.129]	[1.143]	[0.949]	[1.478]	[1.493]	[1.443]	[1.744]	[1.485]	[1.481]	[1.763]	[1.091]	[1.775]	[1.448]
Average class size	2.256***	0.870	1.477***	1.791***	0.203	1.701**	0.570**	0.625*	–0.359*	0.858	–0.707**	1.329***	–1.155
	[0.636]	[0.566]	[0.380]	[0.601]	[0.277]	[0.783]	[0.241]	[0.333]	[0.206]	[0.665]	[0.298]	[0.449]	[1.012]
Teacher shortage	–2.281	–10.630***	1.215	–12.070**	–4.233	–3.733	0.123	–0.336	–4.319**	2.381	9.039***	1.280	0.446
	[4.609]	[2.283]	[1.664]	[5.324]	[2.963]	[3.194]	[3.004]	[4.264]	[1.685]	[2.551]	[2.761]	[5.183]	[2.944]
Female student	–11.769***	–9.326***	–7.009***	–9.874**	1.268	–11.796***	–3.965	–23.765***	5.321*	–0.188	–10.303***	–3.577	0.828
	[3.997]	[3.064]	[2.305]	[3.870]	[3.003]	[2.722]	[3.066]	[2.579]	[3.139]	[3.703]	[2.844]	[3.204]	[3.456]
Migration background: first generation	–35.519***	–9.686**	–6.086	–49.082***	–58.706**	–32.195***	–23.003	–43.112***	–21.747	–22.897	–47.386**	–16.846	14.649*
	[8.474]	[4.788]	[4.629]	[14.601]	[27.260]	[6.927]	[15.703]	[15.813]	[20.300]	[14.903]	[21.192]	[43.729]	[7.871]
Migration background: second generation	–36.636***	–31.825***	–12.124	–34.450***	–79.701***	–19.481***	1.782	4.967	–30.929	14.358	–38.395***	34.462	0.000
	[6.897]	[9.808]	[7.357]	[12.642]	[16.283]	[6.635]	[10.613]	[8.013]	[20.233]	[9.048]	[8.897]	[28.111]	[0.000]
Foreign language spoken at home	–30.334***	–25.596***	–3.411	–1.757	–6.008	–26.417***	–28.464***	–18.845	–35.992**	–84.296***	–5.474	–104.619***	5.045
	[8.343]	[6.040]	[7.356]	[13.795]	[12.892]	[6.144]	[8.909]	[12.120]	[15.737]	[13.616]	[11.163]	[21.964]	[29.504]
Number of observations	4 182	6 246	14 538	5 112	4 284	3 270	3 467	4 014	3 294	3 492	14 420	5 485	4 921
R-squared	0.432	0.448	0.109	0.377	0.106	0.479	0.389	0.496	0.094	0.184	0.334	0.351	0.255

Table 5. **Estimates of the socio-economic gradient in OECD countries: the impact of heterogeneity in the school environment** *(cont.)*

	Luxembourg	Mexico	Netherlands	New Zealand	Norway	Poland	Portugal	Slovak Republic	Sweden	Switzerland	United Kingdom	United States
Individual background	16.690***	7.714***	9.979***	39.934***	29.216***	36.234***	18.034***	20.520***	30.535***	20.641***	34.881***	31.795***
	[1.502]	[0.869]	[1.105]	[2.146]	[1.977]	[1.509]	[1.281]	[1.526]	[2.294]	[1.628]	[2.274]	[1.967]
School environment	48.895***	24.484***	87.607***	33.240***	28.955**	13.518*	18.983***	55.758***	22.454***	52.701***	50.186***	22.614***
	[5.438]	[3.732]	[7.352]	[8.518]	[11.056]	[7.972]	[4.297]	[9.304]	[7.537]	[5.429]	[7.520]	[7.098]
School-level ESCS standard deviation	–10.823	–17.459	80.293***	–5.557	2.026	16.978	15.020	–18.543	4.322	4.948	0.728	42.986*
	[13.609]	[11.290]	[23.794]	[14.815]	[15.819]	[19.486]	[13.651]	[23.838]	[16.544]	[14.554]	[16.240]	[24.957]
Index of quality of educational resources	5.250***	3.419*	8.154***	–3.495	–5.695	–1.447	–0.974	–3.042	3.891	4.325**	–0.679	1.921
	[1.503]	[2.051]	[2.918]	[2.519]	[4.115]	[2.172]	[2.733]	[3.959]	[2.446]	[1.936]	[2.582]	[2.864]
Private government dependent school	4.233	0.000	5.693	0.000	0.000	–17.653	12.387	10.220	22.638	–12.964	0.882	–12.359
	[5.379]	[0.000]	[7.364]	[0.000]	[40.915]	[23.190]	[20.492]	[14.451]	[22.399]	[54.348]	[19.352]	[15.293]
Public school	0.000	18.702	0.000	–9.579	–40.368	–22.567	4.788	19.239***	0.000	45.330***	–0.753	–6.968
	[4.483]	[11.761]	[5.046]	[9.238]	[37.834]	[21.400]	[21.365]	[6.950]	[22.697]	[13.381]	[12.922]	[11.416]
Proportion of certified teachers	35.842***	–11.285*	–4.277	–4.596	–22.403***	25.941	3.826	14.437	75.488***	–8.360	5.820	–5.656
	[12.045]	[6.200]	[13.970]	[6.577]	[7.426]	[20.398]	[13.528]	[16.856]	[26.149]	[6.962]	[18.116]	[23.679]
Ratio of computers for instruction to school size	3.915	40.392	–180.837***	17.250	18.044	0.145	119.194	272.316***	25.779	19.889	–14.671	–17.979
	[9.691]	[36.156]	[39.716]	[23.920]	[39.939]	[37.200]	[72.419]	[80.312]	[30.638]	[16.739]	[23.610]	[18.318]
Average student learning time at school	10.420***	5.864***	6.985***	10.645***	5.353***	5.310**	12.504***	3.629***	7.819***	8.336***	7.374***	9.494***
	[1.885]	[1.145]	[1.711]	[2.048]	[1.779]	[2.215]	[1.571]	[1.301]	[2.628]	[1.518]	[2.256]	[2.005]
Average class size	–0.172	0.402**	0.996	0.592	–0.177	0.721	0.651	0.823	0.301	1.515**	–0.541	0.191
	[0.568]	[0.166]	[0.607]	[0.692]	[0.265]	[0.712]	[0.505]	[0.654]	[0.537]	[0.613]	[0.764]	[0.825]
Teacher shortage	12.253***	0.698	1.122	–5.533**	1.303	0.470	–6.897	–11.738***	3.079	–1.521	–3.880*	1.186
	[2.546]	[2.013]	[3.146]	[2.530]	[3.567]	[4.860]	[4.277]	[3.641]	[3.067]	[2.276]	[2.313]	[2.836]
Female student	–7.069**	–8.643***	–12.520***	–6.796*	3.856	–1.673	–2.193	–10.207***	–0.360	–13.930***	–10.512***	–5.117*
	[2.707]	[2.745]	[2.424]	[3.921]	[3.787]	[2.339]	[2.385]	[3.191]	[2.848]	[2.316]	[2.888]	[2.597]
Migration background: first generation	–22.716***	–37.027***	–30.342***	–5.829	–37.079***	40.818	–32.554***	–22.822	–9.683	–34.738***	–4.316	–3.265
	[4.431]	[10.721]	[5.848]	[5.986]	[10.793]	[57.433]	[9.225]	[18.419]	[8.431]	[4.048]	[6.885]	[7.413]
Migration background: second generation	–22.392***	–65.729***	–27.326***	–7.546	–17.753	–86.461**	–49.162***	–44.724	–27.641**	–55.692***	–12.986	–8.402
	[5.135]	[11.224]	[9.490]	[6.424]	[14.385]	[42.389]	[9.623]	[30.291]	[10.776]	[5.809]	[10.839]	[9.815]
Foreign language spoken at home	–22.493***	44.471	–13.254*	–28.072***	–9.937	1.888	8.012	–13.251	–27.341***	–24.212***	–9.808	–15.404**
	[4.358]	[27.115]	[7.333]	[6.940]	[10.769]	[15.796]	[8.750]	[22.660]	[8.432]	[4.528]	[11.191]	[6.797]
Number of observations	3 957	13 041	4 012	3 659	3 868	5 126	4 182	4 448	3 569	8 953	9 818	4 030
R-squared	0.369	0.319	0.535	0.232	0.099	0.164	0.307	0.306	0.150	0.362	0.204	0.209

Notes: Regression of student science performance on student PISA index of economic, social and cultural status (ESCS), individual control variables (migration status and language spoken at home), school-level ESCS (average across students in the same school, excluding the individual student for whom the regression is run), school–level standard deviation in student socio-economic background (calculated using student-level weights), and school-level controls (school location, school size and school size squared, index of quality of educational resources, index of teacher shortage, proportion of certified teachers, ratio of computers for instruction to school size, average class size, average student learning time at school, school type: private independent, private government dependent, public), regressions for Italy include regional fixed effects (not reported). Country-by-country least-square regressions weighted by student sampling probability. Robust standard errors adjusted for clustering at the school level. Regressions for Italy include regional fixed effects.
Balanced repeated replicate variance estimation, standard errors clustered by school in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions include a constant.
Source: OECD calculations based on the 2006 *OECD PISA Database*.

and country-level variables is restricted to be equal across countries. The difference between equations (4a) and (4b) is that equation (4b) allows country-specific intercepts whereas equation (4a) allows estimating the direct impact of country-specific variables. Because of the presence of country fixed effects, equation (4b) is to be considered as less restrictive in terms of cross-country homogeneity assumptions.

The choice of the control variables included in models (4a) and (4b) is based on the "education production function" approach (see *e.g.* Hanushek, 1994). The variables included are: individual characteristics (gender, migration status and language spoken at home), school location (small town or village, city), school size and school size squared, school resources (index of quality of educational resources, index of teacher shortage, proportion of certified teachers, ratio of computers for instruction to school size), average class size, average student learning time at school, and school type (private independent, private government dependent, public). These variables are allowed to have a heterogeneous impact across countries. Therefore, the findings on the impact of country-level features on equity in student achievement do not depend on the country-level effect of student and schools characteristics on student performance.[23] Baseline estimates of equation (4a) also include GDP per capita as a control variable, as usually done in comparable empirical studies.

3.2.2. How policies and institutions are modelled

Policies and institutions are introduced in the model by assuming that the influence of student and school socio-economic background varies across institutional regimes. In this specification, it is no longer required that parameters β_w and β_b and are equal across countries. These parameters are made regime-specific, by introducing policy interaction terms:

$$Y_{isc} = \alpha_1 + \beta_w \cdot F_{isc} + \beta_b \cdot \overline{F_{sc}} + \delta_w \cdot P_c \cdot F_{isc} + \delta_b \cdot P_c \cdot \overline{F_{sc}} + \gamma_c \cdot X_{isc} + \chi_c \cdot Z_{sc} + \phi \cdot P_{c\cdot} + \psi \cdot W_{c\cdot} + \varepsilon_{isc} \quad (5a)$$

$$Y_{isc} = \alpha_1 + \beta_w \cdot F_{isc} + \beta_b \cdot \overline{F_{sc}} + \delta_w \cdot P_c \cdot F_{isc} + \delta_b \cdot P_c \cdot \overline{F_{sc}} + \gamma_c \cdot X_{isc} + \chi_c \cdot Z_{sc} + \theta \cdot C_{c\cdot} + \varepsilon_{isc} \quad (5b)$$

where P_c denotes policies or system-level features. Specifications (5a) and (5b) identify whether institutional features affect the impact of student and school background on achievement. In specification (5b), which includes country fixed effects, it is not possible to estimate the direct effect of institutional features on student performance, given that those do not vary within countries.

Variants of models (5a) and (5b) are estimated, depending on the nature of the policy under consideration. While both policy interaction terms may be relevant for education policies, it can be argued that welfare, redistributive and labour market policies are generally targeted towards households or individuals and should, therefore, have no direct impact on school environment effects. Thus, for these policies, only the interactions with the individual background, within-school effect are considered. In this case, the model is further relaxed by assuming that the impact of schools' socio-economic background is country-specific. In terms of the above equations, only parameter δ_w does not vary across countries (but varies across institutional regimes).[24]

As already mentioned, specification (5b) is more restrictive in terms of model assumptions than specification (5a) but it provides estimates of the direct impact of policies on student achievement. Hence, in theory it might allow investigating whether

there is a trade-off between efficiency – increasing students' overall performance – and equity – reducing the dependence of performance on socio-economic background. However, caution is needed in this respect. Due to the very limited degrees of freedom under which the corresponding parameter is estimated, the specification cannot provide a consistent estimate of the causal impact of system-level features on student performance. As will appear clear below, given the very unrestricted nature of the model in terms of country heterogeneity, the direct impact of policies on performance is weakly identified. Moreover, the main purpose of this analysis is to assess the influence of policies on equity in education, rather than gauging the average impact of institutions on student and school performance, which is extensively discussed in PISA reports (see, for instance, OECD, 2007a). Hence, discussion of regression results will focus on interaction effects, rather than the direct impact of policies.

The institutional features are all measured at the country level. While most of them are systemic by definition and, therefore, do not vary within countries, others have a within-country dimension, such as school level policy settings – class sizes, proportion of qualified teachers, school selectivity, or ability grouping.[25] These variables are, however, averaged at the country level (using school weights), and the analysis only uses between-country variation in policies and institutions. Indeed, the extent of within-country variation in school-level features is very low and selection bias, whereby students with the same parental background would be found in schools applying certain policies,[26] would make the identification of causal effects difficult. For example, rich families are likely to opt to send their children to schools with high resource levels or highly-qualified teachers. Also, in systems where countries provide disadvantaged areas with additional resources, it is possible to observe an opposite selection bias, whereby disadvantaged students self-select into targeted schools that display specific features – such as lower class sizes. Relying only on between-country variation in policies also makes it easier to interpret results from a policy perspective.[27] However, one drawback of this approach is that the degrees of freedom at the country level are limited, which prevents from investigating potential interactions among policies themselves, and in their relationship with equity in student performance. It is also impossible to introduce various policies simultaneously in the equation, with the associated risk that one policy-specific effect might capture the effect of another, omitted and correlated policy.[28]

The cross-country regressions include a maximum of 27 OECD countries. Due to the heterogeneity of Turkey and Mexico in terms of overall socio-economic background, these OECD countries are excluded from the sample. Indeed, the average ESCS level for students in these countries is a full standard deviation below the international mean, suggesting that the comparisons between these countries and the rest of the OECD countries in terms of equity in educational achievement may be misleading. Also, France is excluded from the regressions since school principals did not respond to the PISA school questionnaire.[29]

3.2.2.1. Interpretation of the interaction effects. As already mentioned, specifications (5a) and (5b) make it is possible to measure how within- and between-school socio-economic effects vary across institutional regimes. Indeed, the impact of school and family background varies across systems as follows:

$$\frac{\partial Y_{isc}}{\partial F_{isc}} = \beta_w + \delta_w \cdot P_c \text{ and } \frac{\partial Y_{isc}}{\partial \overline{F}_{sc}} = \beta_b + \delta_b \cdot P_c \qquad (6)$$

A positive δ means that equity in education achievement decreases ($\beta + \delta > \beta$) while a negative δ means that it increases ($\beta + \delta < \beta$) with the relevant policy.

Alternatively, specification (5a) also allows calculating the influence of policies at different levels of the school and/or students' socio-economic background, as follows:

$$\frac{\partial Y_{isc}}{\partial P_c} = \phi + \delta_w \cdot F_{isc} + \delta_b \cdot \overline{F_{sc}} \qquad (7)$$

In order to ease the interpretation, the policy variables are mean-centred so that coefficient ϕ is to be interpreted as the impact of policy P at the cross-country average of the schools' and students' socio-economic background distribution.[30]

Difficulties in identifying proper causal relationships between policies and equity in educational achievement are enormous with the data at hand. As already mentioned, it is not possible to disentangle nature from nurture effects in the (overall or within-school) gradient estimation, nor is it possible to disentangle contextual from endogenous effects in the between-school gradient estimation. Indeed, estimated within- and between-school gradients are descriptive of the distribution in school performance, and should not be interpreted in a causal sense. Yet, cross-country differences in the distribution of within- and between-school gradients are likely to reflect to a large extent differences in policies and institutions. Therefore, cross-country regression results concerning the role of policies should not be influenced by the empirical limitations attached to the interpretation of the estimated gradients. However, in order to properly identify the causal impact of policies, one would need to be in a natural experiment setting, arising when specific reforms are put in place within countries, and implemented differentially across "treated" and "control" groups (such as the Pekkarinen *et al.,* 2006 study on Finnish education reform in the 1970s). Nonetheless, the cross-country analysis can still identify a number of policies and institutions that are associated with higher levels of equity in educational achievement, and, as such, potentially playing some role in influencing intergenerational social mobility.

3.3. Results on policies and equity in education achievement[31]

3.3.1. Education policies

Results of cross-country regressions in this section confirm that increasing education spending has an ambiguous link with equity in educational opportunities, but other aspects of the education system, such as differentiation policies and financial incentives embedded in teachers' remuneration, have a significant association with equality of learning opportunities.

3.3.1.1. Education policies and school practices. One robust and common finding is that early differentiation of students' curricula tends to be associated with larger socio-economic inequalities, with no corresponding gains in average performance. Both cross-country and country-specific studies have highlighted the negative impact of ability tracking on educational socio-economic inequalities (for cross-country evidence, see OECD, 2004, 2007a, Schutz *et al,* 2005, Hanushek and Woessmann, 2005, Sutherland and Price, 2007, Duru-Bellat and Suchaut, 2005, Amermuller, 2005; for country-specific evidence, see *e.g.* Bauer and Riphahn, 2006, Pekkarinen *et al.,* 2006, Holmlund, 2006, and Bratberg *et al.,* 2005).[32]

Regression results confirm earlier findings according to which educational early tracking increases socio-economic segregation between schools. Interpreting results causally, when educational tracking is brought forward by one year, the impact of a school's

environment on student performance would increase by 8.2 PISA science-score points. Bringing forward tracking is associated with a much lower decrease in the within-school relationship between students' socio-economic background and science performance, by 2.9 PISA science-score points. Implied changes in the school environment effect are quantitatively high, as they would range between 27.7 (PISA score points) in systems with no tracking before age 16 to 77.1 (PISA score points) in systems with early tracking.[33, 34] A similar negative link with equity in educational achievement is found for the number of school types programmes available to 15-year olds. This system-level variable indeed captures the existence of early differentiation and, in this setting, polarisation of the schooling system along socio-economic lines. Comparable results emerge also for selection policy and ability grouping within schools.

Enrolment in vocational education is also associated with a higher impact of schools' socio-economic background on student performance and a lower impact of an individual's background on student performance (Table 6a). Because disadvantaged students are overrepresented in vocational training, it is found to exacerbate school socio-economic inequalities, without increasing overall performance. This result is consistent with empirical evidence on the German case. Buchel (2002) shows that lower-educated school leavers are selected into apprenticeships with less favourable employment prospects and, over time, they also find it increasingly difficult to transfer successfully from apprenticeship to work.

However, the long-term effects of apprenticeship on individuals' economic outcomes are controversial.[35] Moreover, there are substantial differences across OECD countries in the way vocational education is designed, which could lead to different implications for equity in education achievement. Some studies found positive effects of vocational education on equity; in the French case, Bonnal *et al.,* (2002) show that disadvantaged students who tend to opt for apprenticeships gain by being more likely to find a job than those who obtained a mere school-based vocational education. Therefore, it is difficult to draw any clear-cut policy conclusion from cross-country empirical results.

3.3.1.2. Education policies and resources. The cross-country evidence available suggests insignificant effects of aggregate spending variables (Schutz *et al.,* 2005, for example). Some country studies show that increasing educational spending on disadvantaged students or schools does not help increase equity (for the Netherlands, Leuven and Oosterbeek, 2007; for France, Benabou *et al.,* 2004; for the United States, Hanushek, 2007). Other studies suggest that targeted spending can reduce educational inequalities. Using highly disaggregated school data at the territorial level, Bratti *et al.,* (2007) suggest that differences in specific resources can explain geographical differences across Italian regions. Piketty and Valdenaire (2006) show that in France class size reductions at the primary and secondary levels would be particularly beneficial to disadvantaged students. A similar result on class size is suggested by Krueger (1999).

The regression results in Table 6b confirm that educational spending *per se* is not significantly associated with student performance (Schutz *et al.,* 2005, for example), even though it is weakly correlated with higher equity in educational achievement within schools (as suggested by the negative sign of the student socio-economic background interaction in the regression with country fixed effects). Some studies show that increasing educational spending on disadvantaged students or schools does not help increase equity (for the Netherlands, Leuven and Oosterbeek, 2007; for France, Benabou *et al.,* 2004; for the

United States, Hanushek, 2007). Other studies suggest that targeted spending can reduce educational inequalities (Bratti *et al.*, 2007). Table 6b indeed suggests that while the level of spending is not found to be very relevant, the quality of allocation mechanisms, as measured by OECD indicators of "spending decentralisation" and "mechanisms to match resources to needs" appears to be positively related to equity in educational achievement.[36] Indeed, the ability to prioritise and allocate resources efficiently has a very significant negative impact on educational inequalities associated with school environment, while being associated with a smaller negative impact on equity within schools. Decentralisation between central government and sub-national public authorities can improve efficiency in the allocation of public spending resources to the extent that it allows adapting to differing local circumstances; in the same vein, spending mechanisms aimed at supporting the disadvantaged can reduce educational inequalities associated with school environment.

Regression results suggest that lower class sizes at the secondary and primary levels are associated with lower school environment effects: namely, reducing class size is found to increase disadvantaged schools' performance, relative to that of advantaged schools (Table 8b). This is consistent with Piketty and Valdenaire (2006), who show that in France class-size reductions at the primary and secondary levels would be particularly beneficial to disadvantaged students. A similar result on class size is suggested by Krueger (1999). This result can be interpreted along two main lines. First, it can be argued that reducing class size is a useful tool for increasing performance in poor areas, where relatively more resources might be needed to cope with educational disadvantages. Second, insofar as the impact of school socio-economic background captures the contextual and peer effects arising within classes, one alternative interpretation is that these effects are lower in small classes because there is less scope for pupil interaction. This idea, which emerges from recent educational studies on contextual effects (Levin, 2001), points to the difficulties associated with the interpretation of contextual effects from a policy perspective.[37] Indeed, if class size reduction is associated with lower impact of school socio-economic background merely because it reduces student interaction and peer effects, then it might not be the most effective tool for promoting educational equity.

Higher ratios of students to teaching staff are found to be negatively related with equity in educational achievement both between and within schools (Table 6b). Student-teacher ratios measure the total teaching staff relative to students within schools. Thus, it is not only class size *per se* that matters, but also the number of teachers relative to a school's population. Countries displaying relatively high ratios of teachers per student would, therefore, seem to be able to attenuate the influence of school socio-economic disparities on performance while at the same time coping better with disadvantaged students within schools.[38]

There is no empirical evidence on the impact of teacher quality on educational equity. This may be due to the methodological difficulties of measuring teacher quality (see discussion by Vignoles *et al.,* 2000), as well as the endogeneity in the distribution of teachers across schools, in that better teachers may choose to teach in relatively advantaged schools. However, there is some US evidence on the positive relationship between teacher quality, as measured by salaries and experience, and student outcomes (Hanushek. *et al.,* 1998, Dewey *et al.,* 2000, Goldhaber, 2002). Recent cross-country evidence has supported this view (Dolton and Marcenaro-Gutierrez, 2009). If teacher quality matters for student performance, it is arguable that it should matter all the more for that of

disadvantaged students. The effect of measures providing financial incentives to teachers is less controversial (Lazear, 2003). Studies in the United Kingdom (Atkinson *et al.,* 2004) and Israel (Lavy, 2004) have shown that monetary incentives to teachers can have powerful effects on student performance. However, in practice, designing and implementing performance-related schemes has not always proved successful, as discussed in OECD (2005d). From an equity perspective, such policies incur a real risk of exacerbating inequalities across schools by giving teachers incentives to move into advantaged schools. To promote equity, financial incentives for teachers can be targeted at disadvantaged schools or students (Lavy, 2002).

Table 6b shows that the individual background effect is relatively lower in countries where teachers' wage progression is higher. The variable used in this setting does not cover performance-based pay but rather proxies for cross-country differences in teachers' social status, as measured by their expected earnings growth. Experienced teachers might be more motivated to work with disadvantaged students if appropriately remunerated. Since there is evidence that experience is a key dimension of teachers' qualifications,[39] this might signal that financial incentives for attracting qualified or experienced teachers are an effective tool for promoting equity in educational achievement. Studies in the United Kingdom (Atkinson *et al.,* 2004) and Israel (Lavy, 2004) have also shown that monetary incentives to teachers can have powerful effects on student performance. However, in practice, designing and implementing performance-related schemes has not always proved successful, as discussed in OECD (2005d). From an equity perspective, such policies incur a real risk of exacerbating inequalities across schools by giving teachers incentives to move into advantaged schools. To promote equity, financial incentives for teachers can be targeted at disadvantaged schools or students (Lavy, 2002).

There is sparse empirical evidence on the impact of teacher quality on educational equity. This may be due to the methodological difficulties of measuring teacher quality (see discussion by Vignoles *et al.,* 2000), as well as the endogeneity in the distribution of teachers across schools, in that better teachers may choose to teach in relatively advantaged schools. However, there is some US evidence on the positive relationship between teacher quality, as measured by salaries and experience, and student outcomes (Hanushek *et al.,* 1998, Dewey *et al.,* 2000, Goldhaber, 2002). Recent cross-country evidence has supported this view (Dolton and Marcenaro-Gutierrez, 2009). Similar conclusions are reached when estimating the impact of cross-country differences in the proportion of qualified teachers, as measured through the corresponding PISA synthetic indicator. Indeed, a higher proportion of qualified teachers is associated with a lower impact of socio-economic background within schools, suggesting that raising teachers' skills might help in promoting educational equity.[40]

3.3.2. Early schooling and childcare policies

While there is a consensus on the importance of early intervention for intergenerational social mobility,[41] cross-country quantitative evidence on the relationship between childhood policies and equity in education is scarce. This is due to lack of data on a cross-country comparable basis and, hence, the difficulty of identifying the impact of pre-school institutions. One exception is Schutz *et al.,* (2005), who provide empirical cross-country evidence that early enrolment and duration of pre-school are positively related to student achievement.[42] Countries' experience suggests that policy measures to increase equality of learning opportunities through interventions in early childhood have the

potential to yield very high returns. Evidence for the United States – mostly based on scientific evaluations of experimental set-ups, such as the Perry pre-school – is abundant (Carneiro and Heckman, 2003; Blau and Currie, 2006; Cunha *et al.,* 2006).[43] European evidence is more scattered. Some specific examples of the economic benefits of early education on disadvantaged individuals include Leuven *et al.,* (2004) for the Netherlands, as well as Kamerman *et al.,* (2003) for France, Sweden, and the United Kingdom.

Against this background, the present study provides an important contribution to the literature on childcare policy. Cross-country regression results presented in Table 6c show that higher enrolment in childcare is associated with higher equity in student achievement, consistent with earlier – mostly country-specific – studies. More precisely, relatively high levels of childcare enrolment appear to be associated with relatively low levels of school environment effects, even though they appear to be associated with relatively high levels of individual background effects. However, this equity-decreasing impact within schools is much lower quantitatively than the equity-increasing impact between schools. This result holds both for measures of enrolment in childcare and early education services, as well as enrolment in day-care and pre-school. In terms of quantitative impact, a tentative calculation assuming causality would suggest that increasing enrolment in childcare and early education services from the lowest OECD level (2%), to the highest (62%) would bring the between-school gradient from a level of 61 (PISA score points) to a level of 12. A similar impact would be found for public expenditure on childcare and early education services, as shown in the last column of Table 6c, delivering comparable results in terms of the magnitude of estimated causal effects.

A number of caveats apply to this analysis. First, the childcare variables should be measured at a time when the relevant PISA cohort was in age of childcare. This is not possible, however, because the series are not available for the period before 2003. Thus, the implicit assumption is that countries' relative positions in terms of those policies have remained unchanged over time. Second, one would ideally want to measure if individual achievement depends on past childcare enrolment. This variable is not available at the individual level in PISA 2006. However, even if it were, endogeneity and selection bias with respect to childcare enrolment would possibly bias its estimated impact.[44]

3.3.3. Social and labour market policies

Empirical evidence suggests the existence of a positive link between cross-sectional income inequality and intergenerational income persistence.[45] As one of the key drivers of income persistence, equality of opportunity could also be influenced by cross-sectional inequality. Yet, the relationship between income inequality and equity in educational achievement has not been studied in the literature. A number of studies have suggested that the countries with the most equal distribution of income at a point in time exhibit the highest earnings mobility across generations. Explanations of this relationship include differences in the returns to education, but also, more broadly, as suggested in D'Addio (2007), the idea that a number of institutional characteristics – redistributive policies, but also labour market institutions – are potentially important for understanding both intergenerational mobility and the level of cross-section inequality.

This section therefore focuses on the relationship between equality of learning opportunities and taxation and social policies across OECD countries. It uses both direct *policy indicators* (for example tax policy measures), but also *outcome indicators* (for example, relative poverty rates) that (at least partly) reflect cross-country differences in institutional

Table 6a. **Individual background and school environment effects:[1] the impact of education policy/school practices, regression results**

	Baseline		Number of years since first tracking		School selection policy		Ability grouping within schools		System-level number of school types programmes		Enrolment rate in vocational education	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Individual background effect of the PISA index of economic, social, and cultural status on performance												
Individual background	21.488***	21.484***	22.879***	22.874***	22.530***	22.527***	21.378***	21.381***	23.147***	23.147***	22.210***	22.201***
	[0.791]	[0.373]	[0.723]	[0.390]	[0.834]	[0.384]	[0.707]	[0.375]	[0.673]	[0.396]	[1.027]	[0.432]
Interaction Individual background x policy			–2.932***	–2.941***	–0.236***	–0.236***	–0.245***	–0.245***	–4.056***	–4.074***	–0.396***	–0.397***
			[0.299]	[0.171]	[0.022]	[0.013]	[0.043]	[0.028]	[0.525]	[0.271]	[0.052]	[0.025]
School environment effect of the PISA index of economic, social, and cultural status on performance												
School environment	46.717***	46.445***	40.738***	40.496***	42.261***	41.985***	46.853***	46.687***	40.839***	40.664***	41.233***	41.059***
	[3.595]	[1.664]	[3.332]	[1.698]	[3.490]	[1.625]	[3.145]	[1.678]	[3.097]	[1.745]	[4.098]	[1.854]
Interaction school environment x policy			8.279***	8.234***	0.719***	0.719***	0.623***	0.633***	10.863***	10.696***	0.986***	0.977***
			[1.353]	[0.777]	[0.110]	[0.061]	[0.211]	[0.123]	[2.222]	[1.277]	[0.241]	[0.122]
Policy			–0.010		0.064		0.589		–0.716		–0.352	
			[2.271]		[0.202]		[0.370]		[3.790]		[0.287]	
Country fixed effects	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Number of observations	132 347	132 347	132 347	132 347	132 347	132 347	132 347	132 347	132 347	132 347	114 133	114 133
R-squared	0.316	0.316	0.320	0.320	0.320	0.321	0.317	0.317	0.319	0.319	0.325	0.326
Number of countries			27	27	27	27	27	27	27	27	24	24

Notes: Regression of student science performance on student PISA index of economic, social and cultural status (ESCS), individual control variables (gender, migration status and language spoken at home), school-level ESCS (average across students in the same school, excluding the individual student for whom the regression is run), school location (small town or village, city), school size and school size squared, index of quality of educational resources, index of teacher shortage, proportion of certified teachers, ratio of computers for instruction to school size, average class size, average student learning time at school, school type (private independent, private government dependent, public). Country–level controls include GDP per capita (in PPP terms) and the direct effect of the considered policy variable (Model 1), or country fixed effects (Model 2). Student science performance on student PISA index of economic, social and cultural status (ESCS) and school-level ESCS are interacted with policy variables, entered one at a time. Country-specific parameters are used for all variables except student science performance on student PISA index of economic, social and cultural status (ESCS), school-level ESCS, and policy interactions.

Cross-country least-square regressions weighted by student sampling probability, rescaled so that each country receives an equal weight, while taking country-specific sample representativeness into account. Robust standard errors adjusted for clustering at the school level. All variables are mean-centred. All regressions exclude Mexico and Turkey.

Balanced repeated replicate variance estimation, standard errors clustered by school in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions include a constant.

1. All education policy variables are drawn from the *PISA 2006 Database*.

Sources: PISA 2006 database and *OECD ADB Database*.

Table 6b. **Individual background and school environment effects:[1] the impact of education policy/resources, regression results**

	Baseline		Spending per student in secondary education[2]		Decentralisation[3]		Matching resources to specific needs[3]		Class size[1]		Class size in primary[2]		Class size in lower secondary[2]		Student-teacher ratio[1]		Student-teacher ratio lower-secondary[2]		Ratio of teacher's salary at top of scale to starting salary[2]		Proportion of qualified teachers[1]	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Individual background effect of the PISA index of economic, social, and cultural status on performanc																						
Individual background	21.488***	21.484***	21.311***	21.306***	21.785***	21.786***	21.084***	21.077***	21.416***	21.413***	18.585***	18.581***	19.421***	19.427***	21.659***	21.658***	21.593***	21.590***	19.727***	19.711***	21.434***	21.434***
	[0.791]	[0.373]	[0.758]	[0.383]	[0.935]	[0.414]	[0.806]	[0.401]	[0.844]	[0.372]	[0.847]	[0.415]	[0.949]	[0.447]	[0.634]	[0.376]	[0.760]	[0.416]	[0.600]	[0.422]	[0.738]	[0.380]
Interaction individual background x policy			–0.356	–0.351**	1.626***	1.634***	1.408***	1.407***	–0.740***	–0.740***	–0.364***	–0.365***	–0.590***	–0.592***	0.491**	0.493***	0.511***	0.512***	–5.939***	–5.972***	–4.601	–4.599***
			[0.411]	[0.151]	[0.220]	[0.160]	[0.286]	[0.164]	[0.131]	[0.091]	[0.126]	[0.117]	[0.121]	[0.104]	[0.187]	[0.135]	[0.160]	[0.128]	[1.050]	[0.904]	[2.834]	[1.625]
School environment effect of the PISA index of economic, social, and cultural status on performance																						
School environment	46.717***	46.445***	47.170***	46.848***	45.505***	45.256***	46.624***	46.491***	46.592***	46.388***	52.057***	51.884***	48.974***	48.903***	47.470***	47.208***	46.720***	46.538***	51.818***	51.334***	46.751***	46.582***
	[3.595]	[1.664]	[3.308]	[1.673]	[4.105]	[1.776]	[3.526]	[1.760]	[3.644]	[1.647]	[3.761]	[1.881]	[4.035]	[1.993]	[3.042]	[1.656]	[3.397]	[1.842]	[2.987]	[1.884]	[3.343]	[1.711]
Interaction school environment x policy			0.325	0.206	–3.100**	–3.167***	–3.974***	–3.904***	1.415*	1.479***	1.894**	1.900***	1.324*	1.341***	2.466***	2.465***	1.886**	1.902***	–4.315	–3.898	0.807	0.913
			[1.656]	[0.619]	[1.333]	[0.746]	[1.451]	[0.723]	[0.748]	[0.430]	[0.735]	[0.527]	[0.677]	[0.508]	[0.888]	[0.583]	[0.729]	[0.533]	[6.523]	[4.286]	[11.278]	[7.540]
Policy			7.338		–0.547		1.229		–1.902		–1.819		–4.206**		–0.304		–0.763		–2.500		–9.589	
			[4.933]		[2.544]		[2.395]		[1.381]		[2.005]		[2.019]		[1.592]		[1.469]		[17.197]		[29.618]	
Country fixed effects	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Number of observations	132 347	132 347	117 809	117 809	118 808	118 808	118 808	118 808	132 347	132 347	98 937	98 937	88 679	88 679	132 347	132 347	102 480	102 480	90 818	90 818	125 015	125 015
R-squared	0.316	0.316	0.319	0.320	0.333	0.334	0.333	0.334	0.316	0.317	0.348	0.348	0.329	0.329	0.316	0.317	0.321	0.322	0.350	0.351	0.317	0.318
Number of countries			26	26	24	24	24	24	27	27	21	21	19	19	27	27	21	21	21	21	26	26

Notes: Regression of student science performance on student PISA index of economic, social and cultural status (ESCS), individual control variables (gender, migration status and language spoken at home), school-level ESCS (average across students in the same school, excluding the individual student for whom the regression is run), school location (small town or village, city), school size and school size squared, index of quality of educational resources, index of teacher shortage, proportion of certified teachers, ratio of computers for instruction to school size, average class size, average student learning time at school, school type (private independent, private government dependent, public). Country-level controls include GDP per capita (in PPP terms) and the direct effect of the considered policy variable (Model 1), or country-fixed effects (Model 2). Student science performance on student PISA index of economic, social and cultural status (ESCS) and school-level ESCS are interacted with policy variables, entered one at a time. Country-specific parameters are used for all variables except student science performance on student PISA index of economic, social and cultural status (ESCS), school-level ESCS, and policy interactions.

Cross-country least-square regressions weighted by student sampling probability, rescaled so that each country receives an equal weight, while taking country–specific sample representativeness into account. Robust standard errors adjusted for clustering at the school level. All variables are mean-centred. All regressions exclude Mexico and Turkey.

Balanced repeated replicate variance estimation, standard errors clustered by school in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions include a constant.

1. *PISA 2006 Database*.
2. *OECD Education at a Glance Database*.
3. Index from Sutherland and Price (2006).

Sources: *PISA 2006 Database*, *OECD Education at a Glance Database*, Sutherland and Price (2007), *OECD ADB Database*.

Table 6c. **Individual background and school environment effects: the impact of early intervention policies, regression results**

	Baseline		Enrolment rate in childcare and early education services[1]		Enrolment rate in daycare and pre-school[1]		Public expenditure on childcare and early education services/GDP[2]	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Individual background effect of the PISA index of economic, social, and cultural status on performance								
Individual background	21.488***	21.484***	21.496***	21.497***	21.478***	21.478***	21.021***	21.014***
	[0.791]	[0.373]	[0.818]	[0.384]	[0.725]	[0.385]	[0.906]	[0.383]
Interaction individual background x policy			0.230***	0.231***	0.243***	0.244***	4.910**	4.983***
			[0.068]	[0.026]	[0.065]	[0.027]	[2.318]	[0.991]
School environment effect of the PISA index of economic, social, and cultural status on performance								
School environment	46.717***	46.445***	45.370***	45.163***	45.399***	45.189***	48.121***	47.869***
	[3.595]	[1.664]	[3.536]	[1.721]	[3.167]	[1.717]	[3.936]	[1.687]
Interaction school environment x policy			–0.773***	–0.762***	–0.822***	–0.810***	–32.206***	–31.265***
			[0.261]	[0.125]	[0.247]	[0.126]	[11.107]	[4.775]
Policy			0.192		0.202		13.236	
			[0.502]		[0.550]		[19.436]	
Country fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
Number of observations	132 347	132 347	123 394	123 394	123 394	123 394	117 809	117 809
R-squared	0.316	0.316	0.315	0.316	0.315	0.316	0.321	0.321
Number of countries			26	26	26	26	26	26

Notes: Regression of student science performance on student PISA index of economic, social and cultural status (ESCS), individual control variables (gender, migration status and language spoken at home), school-level ESCS (average across students in the same school, excluding the individual student for whom the regression is run), school location (small town or village, city), school size and school size squared, index of quality of educational resources, index of teacher shortage, proportion of certified teachers, ratio of computers for instruction to school size, average class size, average student learning time at school, school type (private independent, private government dependent, public). Country-level controls include GDP per capita (in PPP terms) and the direct effect of the considered policy variable (Model 1), or country-fixed effects (Model 2). Student science performance on student PISA index of economic, social and cultural status (ESCS) and school-level ESCS are interacted with policy variables, entered one at a time. Country-specific parameters are used for all variables except student science performance on student PISA index of economic, social and cultural status (ESCS), school-level ESCS, and policy interactions.

Cross-country least-square regressions weighted by student sampling probability, rescaled so that each country receives an equal weight, while taking country–specific sample representativeness into account. Robust standard errors adjusted for clustering at the school level. All variables are mean-centred. All regressions exclude Mexico and Turkey.

Balanced repeated replicate variance estimation, standard errors clustered by school in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions include a constant.

1. *OECD Family Database* and *OECD Education at a Glance Database*.
2. *OECD Social Expenditure Database*.

Sources: PISA 2006 Database, *OECD Education at a Glance Database*, *OECD Family Database*, *OECD ADB Database*.

Table 6d. **Individual background effect: the impact of social and labour market policies,[1] regression results**

	Baseline		Child poverty after taxes and transfers		Gini coefficient		Material deprivation		Tax progressivity rate		Short-term net unemployment replacement rate		Long-term net unemployment replacement rate	
	Model 3	Model 4	Model 3	Model 4	Model 3	Model 4	Model 3	Model 4	Model 3	Model 4	Model 3	Model 4	Model 3	Model 4
Individual background effect of the PISA index of economic, social, and cultural status on performance														
Parental background	21.451***	21.437***	22.325***	22.341***	21.512***	21.507***	20.285***	20.274***	21.599***	21.586***	21.504***	21.504***	20.903***	20.896***
	[0.781]	[0.371]	[0.579]	[0.471]	[0.504]	[0.371]	[0.874]	[0.423]	[0.501]	[0.375]	[0.692]	[0.372]	[0.663]	[0.377]
Interaction parental background x policy			0.229*	0.232***	38.603**	38.972***	0.145*	0.145**	–33.923***	–33.980***	–0.079	–0.078**	0.104***	0.104***
			[0.132]	[0.076]	[17.927]	[8.880]	[0.080]	[0.057]	[7.445]	[3.826]	[0.061]	[0.035]	[0.031]	[0.016]
Policy			–0.610		–86.825		1.282		–34.502		0.866		0.166	
			[0.886]		[119.522]		[1.244]		[50.409]		[0.588]		[0.228]	
Country fixed effects	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Number of observations	132 347	132 347	98 708	98 708	132 347	132 347	107 652	107 652	132 347	132 347	132 347	132 347	132 347	132 347
R-squared	0.320	0.320	0.326	0.326	0.320	0.320	0.346	0.347	0.320	0.321	0.320	0.320	0.320	0.321
Number of countries			20	20	27	27	22	22	27	27	27	27	27	27

Notes: Regression of student science performance on student PISA index of economic, social and cultural status (ESCS), individual control variables (gender, migration status and language spoken at home), school-level ESCS (average across students in the same school, excluding the individual student for whom the regression is run), school location (small town or village, city), school size and school size squared, index of quality of educational resources, index of teacher shortage, proportion of certified teachers, ratio of computers for instruction to school size), average class size, average student learning time at school, school type (private independent, private government dependent, public). Country-level controls include GDP per capita (in PPP terms) and the direct effect of the considered policy variable (Model 3), or country-fixed effects (Model 4). Student science performance on student PISA index of economic, social and cultural status (ESCS) is interacted with policy variables, entered one at a time. Country-specific parameters are used for all variables except student science performance on student PISA index of economic, social and cultural status (ESCS) and policy interactions.

Cross-country least-square regressions weighted by student sampling probability, rescaled so that each country receives an equal weight, while taking country-specific sample representativeness into account. Robust standard errors adjusted for clustering at the school level. All variables are mean-centred. All regressions exclude Mexico and Turkey.

Balanced repeated replicate variance estimation, standard errors clustered by school in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions include a constant.

1. See data appendix for policy variables definitions and sources.

Sources: PISA 2006 Database, *OECD Education at a Glance Database*, Boarini and Mira d'Ercole, 2006, *Going for Growth Database*, *Taxing Wages Database*, *OECD ADB Database*, OECD (2001c), OECD(2008).

settings. Indeed, in previous studies, cross-sectional inequality has been shown to be related to low intergenerational inequality. Moreover, welfare policies, by targeting disadvantaged family situations – either due to permanent factors or to temporary loss of income (*e.g.* loss of employment) – reduce cross-sectional inequality, thereby potentially helping to mitigate intergenerational persistence. At the same time, ill-designed taxation and social policies would also perpetuate welfare dependency, with potentially negative effects on social mobility. The net effect of these policies on educational opportunities is, therefore, an important empirical issue, even though causal relationships are particularly difficult to establish in this area

Cross-country regression results suggest that countries displaying high levels of child poverty are also characterised by a high level of inequality in educational achievement, as indicated by the positive interaction between child poverty rates and the individual background effect (Table 6d). Whichever school environment students face, the penalty associated with coming from a disadvantaged background is stronger in countries where child poverty rates are relatively high.[46] This result, while not interpretable in a causal way, confirms the importance of early child development for educational outcomes. In a social policy context, it points to a strong case in favour of investing in early childhood education as an efficient tool to promote intergenerational equity.[47]

Results also suggest that cross-sectional income inequality and educational opportunities are positively correlated. While this has long been a conjecture in the intergenerational social mobility literature (Andrews and Leigh, 2007; Aaronson and Mazunder, 2005; Blanden, 2008), empirical evidence has been much less conclusive. Table 6d suggests that income inequality, as measured by the Gini coefficient calculated on disposable household income, is associated with higher educational inequalities, as suggested by the higher impact of individual socio-economic background on student achievement. Similar results are found when using indicators of material deprivation, consistent with findings on the role played by child development in the context of intergenerational social mobility. Results linking inequality and poverty to lack of social mobility may underpin some of the further findings on the impact of welfare and redistributive policies on equity in education. Indeed, regression results suggest that tax progressivity is positively associated with learning opportunities. Interpreting these results in a causal way would suggest that the estimated impact of increasing tax progressivity is relatively important: indeed, the variation in the impact of individual family background on teenagers' cognitive skills from minimum to maximum tax progressivity would range from 25.4 (PISA score points) to 12.4. These calculations are only illustrative, but, nevertheless, point to the potential for redistributive policies to help reduce inequality of learning opportunities.

Unemployment benefits might help to alleviate liquidity constraints on the parents of disadvantaged children. At the same time, relatively high levels of such benefits might discourage unemployed parents to take up employment (*e.g.* Bassanini and Duval, 2006). While it is not possible to identify the nature of the indirect mechanisms at work, the empirical results in Table 6d show a negative link between the level of short-term net unemployment benefits and the impact of individual socio-economic background on student performance, while the level of long-term net unemployment benefits has an opposite link. This pattern is consistent with the interpretation that while short-term unemployment benefits help to ensure the transition from job to job and consequently alleviate transitory liquidity constraints, long-term unemployment benefits, might – if

fixed at too high a level – discourage job transition and result in unemployment or welfare-dependency traps. Long-term unemployment benefit dependency may also be associated with social stigma, in turn harming children's cognitive development. This result is consistent with the findings of child development studies relating parent welfare dependency to children's outcomes (Corak and Heisz, 1999; Corak *et al.,* 2004).

4. Concluding remarks

This work has provided measures of equality of educational opportunities across OECD countries. It suggests that the majority of OECD countries exhibit ample scope for increasing educational opportunities for disadvantaged individuals, allowing for coping with both equity as well as efficiency concerns. However, the empirical analysis shows that OECD countries are extremely heterogeneous with respect to educational socio-economic inequalities. In particular, while Nordic countries exhibit relatively low levels of inequality, continental Europe is characterised by relatively high levels of inequality in educational achievement – in particular related to schooling segregation along socio-economic lines – while Anglo-Saxon countries occupy a somewhat intermediate position. Broadly speaking, these results confirm literature findings on intergenerational social mobility (d'Addio, 2007). Causa *et al.,* (2010) discusses the relative positions of OECD countries, comparing income and educational mobility, and discussing methodological limitations of the comparative approach. The analysis also uncovers non-linearities and asymmetries in the impact of school environment on student performance – or the so-called contextual effects: since contextual effects appear to favour disproportionately weak students in a number of OECD countries, increasing schools' social mix is likely to increase equality in educational opportunities without being detrimental to average performance.

Cross-country regressions should not be interpreted as causal relationships. Despite this important limitation, this paper provides a number of relevant findings on the association between equality of educational opportunities and public policies in OECD countries. First, this work confirms earlier findings on the negative impact of early differentiation and tracking policies on educational equality of opportunity. Second, it confirms also the relative weakness and ambiguity attached to the empirical identification of the relationship between educational spending and educational equity. However, the empirical results suggest that an equity-increasing use of educational resources may be obtained through policies that provide the relevant signals to schools and teachers: for instance, providing financial incentives to qualified teachers may prove to be an effective tool for targeting disadvantaged students or areas. Thirdly, this work fills a gap in empirical research by providing cross-country (as opposed to country-specific) evidence on the importance of early intervention policy for attenuating intergenerational socio-economic inequalities in educational opportunities. It suggests that childcare and early intervention policies could be effective to reach this objective. Finally, the cross-country analysis attempts to uncover the role played by social and labour-market policies in influencing equality of educational opportunities, given the positive relationship between intergenerational and cross-sectional (income) inequality. Empirical results suggest that some redistributive and income support policies are associated with lower inequality of educational opportunities.

Once again, given the empirical limitations of the analysis, results on policies and educational outcomes of teenagers do not imply causality. More needs to be done in order to provide empirical estimates of the causal impact of policies on equality of educational

opportunities, either through specific case studies looking at the effects of policy changes, or through the development of more refined cross-country time-series data on individuals and the policies that affected their cognitive skills.

Notes

1. Boarini and Strauss (2008) provide recent cross-country estimates for OECD countries.
2. For example, in the United States, ability test scores of children as young as five have been found to be closely related to family background (income levels, education of parents, family situation, etc.).
3. Throughout this document, the expressions "equality of opportunity", "equity in learning opportunities", or "educational equity" are used interchangeably.
4. PISA data have also been used extensively outside the OECD both in a cross-country perspective (Esping-Andersen, 2004, Fuchs and Woessmann, 2004, Entorf and Lauk, 2007) and in country-specific studies (among others: for Germany, Fertig, 2003a, 2003b; for Italy, in a cross-regional perspective, Foresti e Pennisi, 2007, and Bratti *et al.*, 2007; for Austria, Schneeweis and Winter-Ebner, 2005).
5. For a presentation of PISA, see the latest OECD report (OECD, 2007a) as well as the PISA website (*www.pisa.oecd.org*). For technical documentation on survey design and data analysis, see OECD (2005b, 2005c).
6. This mean refers to the OECD aggregate, using appropriate students' weights.
7. A word of caution is needed here. Indeed, this index contains information on a number of items which can be considered as educational expenditures; those expenditures may vary by country depending on the school system (*e.g.* in some countries students do not have to buy books because they are provided by the school) and not on families' socio-economic status.
8. This mean refers to the OECD aggregate, using appropriate students' weights.
9. OECD (2004, 2007a) presents this index as a measure of "segregation by socio-economic background": intuitively, for a given level of overall variation in students' socio-economic background, systems can be either highly segregated, where students within schools come from identical backgrounds, but average socio-economic background varies across schools, or highly desegregated, where each school is identically mixed in terms of socio-economic background, and there are no differences across schools.
10. The results do not change when this correction is not made. See, for instance, the PISA study which does not exclude the student from the calculation of this average.
11. These are: school location (small town or village, city), school size and school size squared, school resources (index of quality of educational resources, index of teacher shortage, proportion of certified teachers, ratio of computers for instruction to school size), average class size, average student learning time at school, and school type (private independent, private government dependent, public).
12. School selection policy is measured through the PISA school questionnaire. A school is defined as academically selective if principals report that students' academic records and/or students' recommendation of feeder schools are a prerequisite or a high priority for students' admission.
13. Estimates including these controls are not shown for space concerns, but are available upon request.
14. Comprehensive school systems refer to school systems that do not systematically separate students according to ability; students follow generally unified *curricula* across secondary schools.
15. As seen above, this difference does not arise because of distributional differences, given the already high cross-country differences in "uncorrected" gradients.
16. These results on non-linearities in educational opportunities echo some of the findings of intergenerational earnings mobility studies. In particular, both Jannti *et al.*, (2006) and Grawe (2004) show that low mobility in the United Kingdom is the result of very high persistence in the upper tails of the distribution, a finding which is confirmed here.
17. The regressions control for individual characteristics. Due to data unavailability at the school level, France is not included in these estimations.

18. The countries for which the estimated school environment effects are statistically different between urban and rural areas are: Iceland and Poland (at 1% confidence level); Spain and Mexico (at 5% confidence level); and Portugal and the Netherlands (at 10% confidence level). For the Netherlands, which in a comparative perspective exhibits one of the highest levels of socio-economic inequality between schools in both rural and urban areas, the estimated effect is slightly stronger in rural areas than in cities; the opposite pattern is observed in other countries.

19. The Slovak Republic and Ireland also exhibit large differences in school's socio-economic distribution across rural and urban areas. However, the school environment effect is relatively low in those countries.

20. This analysis does not have to be interpreted as a proper estimate of peer effects, given the empirical difficulties of identifying them. Moreover, it has to be kept in mind that the analysis would have to rely on class as opposed to school scores for estimating peer effects. Class level data are not available in PISA.

21. It is not possible to introduce simultaneously achievement scores and socio-economic variables at the school level because of collinearity issues, as extensively discussed in the literature. Some countries are omitted from the regressions because of missing data on some or all school variables.

22. These tentative calculations are simply obtained by multiplying the corresponding estimated coefficients by 100, which is the international standard deviation of PISA science scores.

23. Moreover, contrary to expectations, country-level estimates of the "net" within- and between-schools gradients are not much affected by the introduction of student and school controls. This is the reason why country estimates including school controls are not presented in previous sections, where only estimates accounting for student-level characteristics were discussed.

24. In theory, it could also be possible to estimate variants of the above model where only interactions between the school socio-economic background and policies are considered, controlling for country-specific effects of own socio-economic background. For example, housing policies might be associated with higher or lower contextual effects across schools. Unfortunately, institutional cross-country data on housing or urban policies are currently not available. Moreover, the difficulty of properly identifying and understanding the nature of contextual and peer effects would make interpretation of the results difficult. Hence, this strategy is not followed in the present approach.

25. These variables are directly available in the PISA dataset through the school questionnaire.

26. Schutz *et al.*, (2007) use the same approach for evaluating the impact of school autonomy, accountability and choice on equity in student achievement.

27. An attempt was made to estimate country-by-country regressions on the impact of school policies that display some variation within countries. It revealed the presence of important endogeneity and selection bias issues that made it very difficult to understand the results.

28. Indeed, a preliminary pair-wise correlation analysis reveals very high correlation between policies belonging to the same institutional area. For example, among education policies, the cross-country correlation between number of years since first tracking and system-level number of school types available to 15-year olds is 0.88. Among social and labour market policies, the cross-country correlation between the Gini coefficient on household's disposable income and tax progressivity is 0.90.

29. As discussed above, the estimation controls for the complex survey design of the PISA dataset. Also, student weights are rescaled so that each country receives an equal weight, while maintaining student and school sample representativeness within countries.

30. This average is not regression-specific and includes all OECD countries except Turkey and Mexico.

31. The sources and definitions of policy and institutional variables are provided in the data appendix.

32. Checchi and Flabbi (2007) have a slightly different approach, in that they focus on differences *within* tracking systems. The authors compare Germany and Italy and find that Italy, where parents have more latitude to interfere with the schooling careers of their children, exhibits less equality of opportunity than Germany.

33. This effect refers to the minimum age of first tracking, which is 10 years old across the countries under consideration.

34. These tentative calculations are based on cross-country average estimates and should be interpreted cautiously. The associated effects might be stronger or weaker, depending on countries' specificities.

35. See Machin and Vignoles, 2005, Buchel, 2002.

36. For details on the definition and computation of these educational institutional indicators, see Sutherland and Price (2007).

37. Also, this interpretation is indeed suggestive since this study makes use of *country-level* average class size (either from the school questionnaire averaged through school weights or from the Education at a Glance database), as opposed to *student-level* class size. As explained above, using the PISA class size variable (defined at the school level, and not at the student level, as required in theory for identifying peer effects) is not possible because of endogeneity bias. Moreover, class size at the school level is one of the (country-specific) control variables included in the regressions.

38. One interpretation of this finding could be that the positive association with equity occurs because in some countries students are exposed to different teachers for different topics, while in others the same teachers cover different topics. In this case, the results would not identify the impact of higher resources devoted to each student, but rather the impact of teachers' variety and diversity on equity. Disadvantaged schools and children could benefit disproportionately from being exposed to a diversity of teachers and teaching methods.

39. Greenwald *et al.,* (1996), Hanushek *et al.,* (1998).

40. These results do not take into account the potential endogenous impact of teacher quality on the housing market. Indeed, educational policies aimed at raising school quality in disadvantaged areas can be ineffective if they are internalised in housing markets. For instance, research on France found school quality effects on the Paris area housing markets (Fack and Grenet, 2007). Simulations suggest that a standard-deviation increase in average school quality would raise prices by about 2%, which would imply that the fraction of housing price differentials across school zones that can be explained by school quality differential amounts to about 7% in Paris.

41. See, for example OECD (2007b).

42. More precisely, the authors suggest that only after a certain threshold level is reached enrolment in pre-school has a positive impact on equity, which they interpret as an effect of non-random sorting of well-off children into pre-school at low levels of enrolment.

43. For the United States, a recent study on the effects of pre-kindergarten on children's school readiness shows larger and longer lasting associations with academic gains for disadvantaged children (Magnuson *et al.,* 2007).

44. Another limitation of this analysis is the absence of France, where there are both high levels of childcare enrolment and high estimated school environment effects, potentially contradicting this result. Unfortunately, as mentioned above, French data at the school level are not available in the PISA 2006 survey.

45. Bjorklund and Jsannti (1997); Gottschalk and Smeeding (1997); Aaberg *et al.,* (2002); Andrews and Leigh (2007); Blanden (2008).

46. This model is highly unrestricted and allows for heterogeneity, given that contextual effects are country-specific.

47. See d'Addio, (2007), for a review of the child development literature in the context of intergenerational social mobility, as well as Duncan *et al.,* 1994; Carneiro and Heckman, (2003); and OECD (2001b).

Data Appendix
Policy Variables: Sources and Definitions

This section provides data definitions and sources on policy variables used in the cross-country regressions. The PISA dataset is presented in the main text. Policy variables from the *PISA Database* refer to 2006.

Early intervention and childcare policies: *i)* Enrolment rates of children under the age of six in childcare and early education services (2003 or 2004); and *ii)* enrolment in day-care for children under the age of three and pre-school from three to six years old (2003 or 2004): the sources of these variables are the *OECD Family Database* and the *OECD Education at a Glance Database*. *iii)* Public expenditure on childcare and early education services as a percentage of GDP (2003): the source of this variable is the *OECD Social Expenditure Database*.

Education spending is defined as annual expenditure on educational institutions per student for all services (all secondary) in 2004. The source is *OECD Education at a Glance Database*.

Indicators of spending efficiency ("decentralisation", "matching resources to specific needs") are from Sutherland and Price (2007).

Variables measuring class size and student teacher ratio come from two sources: *i)* the PISA questionnaire, in which case they are averaged at the country level using school weights; *ii) OECD Education at a Glance Database*, where this study makes use of average class size in lower secondary and primary education for public and private institutions and the ratio of students to teaching staff in lower secondary education (2005 data).

The variable measuring **the ratio of the teachers' salary at top of scale** as a proportion of teachers' salary at the minimum training in lower secondary education is drawn from OECD's *Education at a Glance database* (2005 data). The index of **proportion of qualified teachers** is computed in the PISA project. It is based on the school questionnaire and averaged at the country level using school weights.

The variable measuring **ability tracking** within schools is based on the PISA school questionnaire and is constructed as follows. First, a school-level binary variable is created, where a value of one is given when principals report that schools regroup students according to ability in all subjects. Aggregated at the country level, this variable measures the proportion of schools that are estimated to regroup students according to ability. The variable on **school selection policy** is constructed in a similar way, following the school questionnaire; a school is defined as academically selective if principals report that students' academic records, students' recommendation of feeder schools are a prerequisite, or a high priority for student admission. Aggregated at the country level, this variable measures the proportion of academically selective schools.

System-level educational variables on **tracking and vocational education** are available in the *PISA Database*: *i)* age of first tracking, on the basis of which this work constructs the variable "number of years since first tracking", measured as 15 minus the age of first tracking; *ii)* the number of school types of programmes available to 15-year olds; *iii)* the percentage of 15-year olds enrolled in vocational education. The latter variable is computed from the student-level PISA dataset.

Relative **child poverty rate** is defined after taxes and transfers and refers to the 1990s; it is taken from OECD (2001b). The **Gini coefficient** on income inequality is based on OECD (2008) and refers to the mid-2000s. Data refer to the distribution of household disposable income in cash across people, with each person being attributed the income of the household where they live adjusted for household size. **Material deprivation** is measured through household data and defined as the share of household reporting material deprivation in terms of six dimensions (this work uses the synthetic indicator defined as the average of the six dimensions). The data refer to the beginning or mid-2000s and come from Boarini and Mira d'Ercole (2006). The measure of **tax progressivity** is the difference between the marginal and average personal income tax rate, divided by one minus the average personal income tax rate, for an average single production worker. The data are averaged across the years 1995-2004. The source is the *OECD Taxing Wages Database*. Short- and long-term net **unemployment benefits** refer to the year 2002 and are drawn from the *OECD Going for Growth Database*.

Glossary

- **Equality of opportunity:** The concept of equality of opportunity was originally introduced by Roemer (1998) and states that individual achievement should not reflect circumstances that are beyond an individual's control, such as family background.
  - ❖ Throughout this work, the expressions *equality of opportunity, equity in learning opportunities, educational equity, inequalities associated with socio-economic background, or socio-economic inequalities,* are used interchangeably to cover the differences in achievement between students coming from socio-economically advantaged and disadvantaged family backgrounds, or between students attending socio-economically advantaged and disadvantaged schools (identified by the average socio-economic status of the students enrolled in their school).
- **PISA 2006 science score:** This study uses cross-country comparable microeconomic data on student achievement, collected consistently across and within OECD countries through the Programme for International Student Assessment (PISA). PISA aims to assess the skills of students approaching the end of compulsory education. The main focus of the PISA 2006 study is on science literacy, with about 70% of the testing time devoted to this item. Given the very high correlation among science, mathematics, and reading scores, the following analysis focuses on science scores. *The performance in science is mapped on a scale with an international mean of 500 and a standard deviation of 100 test-score points across OECD countries* (aggregate OECD mean, using appropriate student weights).
- **PISA index of economic, social, and cultural status (ESCS):** The PISA ESCS index is intended to capture a range of aspects of a student's family and home background. It is explicitly created by PISA experts in a comparative perspective and hence with the goal of minimising potential biases arising as a result of cross-country heterogeneity. It is derived from the following variables: *i)* the international socio-economic index of occupational status of the father or mother whichever is higher; *ii)* the level of education of the father or mother, whichever is higher, converted into years of schooling; *iii)* the index of home possessions obtained by asking students whether they had at their home: a desk at which to study, a room of their own, a quiet place to study, an educational software, a link to the Internet, their own calculator, classic literature, books of poetry, works of art (*e.g.* paintings), books to help with their school work, a dictionary, a dishwasher, a DVD player or VCR, three other country-specific items, as well as the number of cellular phones, televisions, computers, cars and books at home. *The student scores on the index are factor scores derived from a Principal Component Analysis which are standardised to have an OECD mean of zero and a standard deviation of one* (aggregate OECD mean, using appropriate student weights).

- **(Socio-economic) gradient:** The (socio-economic) gradient measures the relationship between student performance, as measured by PISA 2006 science scores, and student socio-economic background, as measured by the PISA ESCS index.
  - ❖ The (socio-economic) gradient is called "(socio-economic) gradient taking cross-country distribution differences into account" when the estimated gradient is used to predict country-specific differences in student performance associated with the difference between the highest and the lowest quartiles of the country-specific distribution of the PISA ESCS index.
  - ❖ The (socio-economic) gradient can be called "gross (socio-economic) gradient" when the estimated relationship between student performance and student socio-economic background does not include control variables.
  - ❖ The (socio-economic) gradient can be called "net (socio-economic) gradient" when the estimated relationship between student performance and student socio-economic background includes control variables (individual control variables: gender, migration status, language spoken at home).
- **The individual background effect, or within-school effect:** The individual background effect or within-school effect measures the relationship between student performance, as measured by PISA 2006 science scores, and student socio-economic background, as measured by the student-level PISA ESCS index, controlling for school socio-economic background, as measured by the average ESCS level across students within the school.
  - ❖ The individual background effect can be used to predict country-specific differences in student performance associated with the difference between the highest and the lowest quartiles of the country-specific within-school average distribution of the PISA ESCS index, calculated at the student level.
- **The school environment effect, or between-school effect:** The school environment effect or between-school effect measures the relationship between student performance, as measured by PISA 2006 science scores, and school socio-economic background, as measured by the average ESCS index, across students within the school, controlling for student socio-economic background as measured by the student-level PISA ESCS index.
  - ❖ The school environment effect can be used to predict country-specific differences in student performance associated with the difference between the highest and the lowest quartiles of the country-specific school-level average distribution of the PISA ESCS, calculated at the student level.
- **Contextual effects:** Contextual effects arise when the probability that an individual behaves in some way depends on the distribution of exogenous background characteristics in the group: in the present work, student achievement depends on the socio-economic composition of the reference group, measured at the school level.
- **Peer effects:** Peer effects arise when the probability that an individual behaves in some way is increasing with the presence of this behaviour in the group: in the present work, student achievement depends positively on the average achievement in the reference group, measured at the school level. Peer effects are also referred to as endogenous effects.

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Does Computer Use Increase Educational Achievements? Student-level Evidence from PISA

by
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The aim of this paper is to assess whether the use of ICT has an impact on student performances as measured in the OECD Programme for International Student Assessment (PISA) 2006. After controlling for observable students' characteristics and self-selection, we did find a positive and significant effect of the frequency of computer use on science scores. In most countries, however, this effect seems larger when computer is used at home rather than at school. This finding questions the effectiveness of educational policies aimed at promoting computer use at school as a tool for learning.

JEL classification: I20, O33, C25.

Keywords: education, PISA, ICT, computer use, educational policies.

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In recent years the role of Information and Communication Technologies (ICTs) as a tool to raise educational achievements has attracted growing attention from both policy makers and academic researchers. While the former tend to be enthusiastic about the use of ICT in teaching and learning, the latter have found little evidence to support such enthusiasm.

The question is far from academic. Although the value of ICT public investments in school is not known with certainty, there are clear indications that they have been substantial. In OECD countries, the average numbers of computer per student in school doubled in only three years, from 1 to 10 in 2000 to 1 to 5 in 2003. Similarly, while less than a third of OECD secondary schools had Internet access in 1995, access was virtually universal by 2001. This is currently the case for broadband connectivity in a growing number of OECD countries (OECD, 2010).

In more recent time the diffusion of ICTs in education has lost its status as a policy priority, but investments have not ceased. As the OECD observes (2010) "education systems keep investing in technology in the belief that, sooner or later, schools and teachers will adopt it and benefit from it". Therefore, the question is: are ICT public investments in schools paying back?

Assessing the impact of computer use on student performances raises the same methodological issues as any programme evaluation. A comparison between those who use the computer (*treated*) and those who do not (*control group*) would be legitimate only if the students in these two groups had similar characteristics. Unfortunately, there are two major reasons to expect that this is not the case.

First, the factors that affect computer use, *e.g.* family background, also have an impact on student performances. Therefore, a positive correlation between computer use and student performance may simply capture the effects of a better family background (*spurious correlation*).

Second, while some of the above factors can be measured, others can only be measured with an error, *e.g.* skills and interests, or are not observable at all, *e.g.* attitudes. Observed differences in computer use, therefore, may reflect unobservable differences in students' characteristics. In these circumstances, the *treatment* (computer use) becomes *endogenous* because different students *self-select* into different frequencies of computer use.

One further complication in the present context is that our *treatment* (computer use) is not of the type "*treated-untreated*" (use/no use) but it may have different intensities, from high computer use to no use.

The paper deals with *spurious correlations* and *endogeneity* within a non-dichotomous "endogenous treatment model" (Vella, 1998), where the treatment consists of a discrete number of frequencies of computer use. Such a model permits to predict the frequency of computer use based on observable students' characteristics (*selection*) and to estimate the effects on student performances associated with each frequency of use (*outcome*).

The paper is organised as follows. Section 1 reviews previous studies about the relationship between ICT use and student performance. Section 2 introduces the econometric model used in this study to address these issues and its application to the PISA 2006 data. Section 3 looks at the factors that affect the frequency of computer use by students, while Section 4 identifies the factors that influence student performances. Section 5 focuses on the returns from computer use at home and at school. Finally, Section 6 discusses the main policy implications of the paper.

1. Findings from previous studies

The role of ICTs in classrooms and their impact on students' performances have been the focus of an extensive literature over the last two decades. Earlier contributions have explored the effects of computer use, while more recent studies have focused on the impact of online activities: Internet, educative online platforms, digital devices, blogs and wikis, etc.

This body of literature shows mixed results. Some studies found no significant effect of ICTs on education outcomes while others point out to a sizeable impact of ICTs on students' achievement. Both theoretical and empirical arguments may explain these mixed results.

On theoretical grounds, ICTs can be regarded as a more "productive" input in the student learning process. They can help students to acquire information for schooling purposes and to access a wider range of educational resources at home at any time of the day.

However, ICT use in the classroom may also displace more effective teaching techniques. Some ICT applications, such as chat rooms or online games, can distract from learning at home. In addition, ICT-based applications could restrict the creativity of the learner as ICTs only allow for a pre-defined set of interactions.

The educational benefits from ICTs also depend on the capability of schools to change their organisation and teaching methods in a way that is complementary to ICT use. Indeed, the economic literature on the "productivity paradox" (Brynjolfsson and Hitt, 2000) suggests that organisational change may be the key to unleashing the educational potential of ICTs.

Thus, the theory suggests that the impact of ICTs on student learning strongly depends on their specific uses and on the environment in which they are used.

On the empirical side, the positive effects of ICT use are generally inferred from a positive correlation between ICT and student performance (see Kirkpatrick and Cuban,1998, for example). However, to the extent that the use of computer and teaching software are correlated with other inputs to education *e.g.* social background, parents' education, etc., better student performance may well be a result of the latter rather than the effect of ICT use (*spurious correlation*).

Fuchs and Woessman (2004), for example, find a positive and significant correlation between the availability of computers at school and school performance in PISA; however, the correlation becomes small and insignificant when other school characteristics are taken into account.

A second issue arises from the fact that different choices about the frequencies of ICT use may reflect unobservable differences in student characteristics, such as skills, attitudes or interests. As a consequence, one cannot compare student performance between ICT users (*treated*) and non-users (*control group*) because the two groups are

different. In these circumstances, the treatment becomes *endogenous* as different students *self-select* into different frequencies of computer use.

Some studies have tried to control for the endogeneity of ICT use, either using *experimental data* (Coates *et al.,* 2004; Rouse *et al*., 2004; Anstine and Skidmore, 2005; Banerjee *et al*., 2004) or exploiting *changes in policy* (Angrist and Lavy, 2002; Goolsbee and Guryan, 2002; Leuven *et al.,* 2004; Machin *et al*., 2006).

Coates *et al*. (2004) compared student scores in face-to-face and online economics courses taught at three different institutions. After taking into account selection bias and differences in student characteristics, they report that the average scores are almost 15% higher for the face-to-face format than for the online format.

Rouse *et al*. (2004) present results from a randomised study of a popular instructional computer programme designed to improve language and reading skills in the United States. Their estimates suggest that while the use of computer programmes may improve some aspects of students' language skills, these gains do not translate into a broader measure of language acquisition or into actual reading skills.

Anstine and Skidmore (2005) surveyed two matched pairs of on-campus and online courses, one in statistics, and the other in managerial economics. They report that after taking into account student characteristics and selection bias, students in the online format of the statistics class exam scored 14.1% less than in the traditional format, whereas, for the managerial economics class, the test scores within both formats were not significantly different.

Angrist and Lavy (2002) analyse the effects of a large-scale computerisation policy in elementary and middle schools in Israel, based on a controlled comparison between schools that received funding and schools that did not. They find no evidence that increased educational use of computers raised pupil test scores. In fact, they even find a negative and significant relationship between the programme-induced use of computers and the 4th grade maths scores.

Goolsbee and Guryan (2002) found that a US programme to subsidise schools' investment in Internet and communications led to an increase in Internet connections but had no impact on any measure of pupil achievement.

Leuven *et al*. (2004) find that the extra funds for computers and software in the Netherlands do not have a positive impact on pupils' achievement, and even seem to have a negative effect on language and maths scores.

In general, those studies controlling for the *endogeneity* of ICT use tend to find no effect or even a negative effect of ICTs on student performances. There are, nonetheless, two noticeable exceptions.

Banerjee *et al*. (2004) present the results of a randomised policy evaluation carried out in two Indian States to improve the quality of education in urban slums. The authors found out that a computer-assisted programme, designed to reinforce mathematical skills, had a large and positive impact on math scores; however, the programme did not produce positive spillovers to other subjects.

Machin *et al*. (2006) evaluated whether changes in ICT investment had any causal impact on changes in educational outcomes in English schools over the period from 1999 to 2003. Using an Instrumental Variable (IV) approach to control for endogeneity of ICT use,

the authors found evidence for a positive causal impact of ICT investment on educational performance in primary schools.

The aim of the present paper is to contribute to this line of research by providing new evidence based on the OECD Programme for International Student Assessment (PISA). The approach and the data source are similar to those by Fuchs and Woessman (2004). Unlike their study, however, the present paper controls for the endogeneity of computer use and provides results by country.

2. The econometric model

The OECD Programme for International Student Assessment (PISA) assesses the extent to which students near the end of compulsory education have acquired the knowledge and skills essential in everyday life. Students are tested in the domains of reading, mathematical and scientific literacy and complete a background questionnaire. In this study, we will focus on the student performance in science. Nonetheless, the scores of the three tests are highly correlated, so that the results presented for science can be generalised to maths and reading as well.

Our aim is to assess whether computer use (IT^*) has an impact on PISA 2006 science scores (*Science*) after having controlled for other observable student characteristics (X):

$$Science_i = \beta' X_i + \delta (IT_i^*) + e_i \qquad [1]$$

where the subscript $i = 1, \ldots N$ indicate the students, X denotes observable individual characteristics; e is an individual idiosyncratic error term which influences the student's science scores; β denotes unknown parameters; and δ is an unknown function which generates increased science scores through additional computer use.

In the PISA 2006 survey we do not observe actual computer use IT* but only the variable IT (computer use frequency) with discrete values: 1 (never), 2 (once a month or less), 3 (a few times a month), 4 (once or twice a week) and 5 (almost every day). This means:

$IT_i = 1$ if $IT_i^* < \mu_1$; $IT_i = 2$ if $\mu_1 < IT_i^* \leq \mu_2$; $IT_i = 3$ if $\mu_2 < IT_i^* \leq \mu_3$; $IT_i = 4$ if $\mu_3 < IT_i^* \leq \mu_4$; $IT_i = 5$ if $\mu_4 < IT_i^*$

We can write the observable computer use frequency as the following j dummy variables based on these discrete values:

$D_{ij} = 1$ if $IT_i = j$, and

$D_{ij} = 0$ otherwise.

Therefore, equation [1] can be estimated through the following empirical model which comprises the reduced form representations of the student's science score and computer use:

$$Science_i = \beta' X_i + \Sigma_{j=1}^{5} \delta_j D_{ij} + e_i, \qquad i = 1, \ldots N \qquad [2]$$

$$IT_i^* = \lambda' Z_i + \upsilon_i, \qquad i = 1, \ldots N \qquad [3]$$

$$D_{ij} = 1 \text{ if } IT_i = j;\ D_{ij} = 0 \text{ otherwise} \qquad i = 1, \ldots N;\ j = 1, \ldots 5 \qquad [4]$$

where X_i and Z_i continue to denote vectors of exogenous characteristics, possibly overlapping; e_i and υ_i are jointly normally distributed error terms with zero means, variances σ_e^2 and σ_υ^2 and covariance; $\sigma_{e\upsilon}$; β, δ and λ are vectors of parameters and the effects of computer use are captured by the δ's.

The system of equations [2] – [4] is known as an "endogenous treatment model". The primary difficulty in consistently estimating the parameters from [2] is the endogeneity of the computer use dummy variables. This is due to the potential for students to choose their frequency of computer use (*self-selection*). In general, therefore, $\sigma_{e\nu} \neq 0$, which implies that computer use is not weakly exogenous to the science score.

Two estimation procedures are available to overcome the inconsistency in [2]. The first procedure consists in estimating IT_i^* in [3]) by Probit and then replacing IT_i with $\hat{IT}_i$ in [4] to generate the dummies D_{ij}. The shortcom]ng of this procedure is that, if $X_i = Z_i$, D_{ij} and X_i are likely to be strongly collinear through Z_i and the estimates of β and δ will have large standard errors. In general, the identification of [2] requires an instrumental variable, although there are frequently few candidates for simultaneous exclusion from X_i and inclusion in Z_i.

The second procedure consists in estimating the corresponding Probit residual in [3], $\hat{\nu}_i$ and including both $\hat{\nu}_i$ and D_{ij} in [2]. The Probit residual is known as a *generalised residual* (Gourieroux *et al.*, 1987). By construction, the $\hat{\nu}_i$ are uncorrelated with Z_i over the whole sample. Therefore, the consequence of a high degree of collinearity between the generalised residual and the Z_i, which is a concern in the first procedure, does not arise. Therefore, this model is identified without exclusion restrictions due to the nonlinearity of the residual.

Equation [2] can be rewritten as:

$$Science_i = \beta' X_i + \sum_{j=1}^{5} \delta_j D_{ij} + \mu\, \hat{\nu}_i + \eta_i \qquad i = 1, \ldots. N;\ j = 1, \ldots. 5 \qquad [2']$$

and be estimated by least squares ($\mu = \sigma_{e\nu}/\sigma_{\nu}^2$ and η_i is a zero mean error uncorrelated with the regressors).

One shortcoming of equation [2'] above is that the coefficients on X_i are constrained to be equal across all frequencies of computer use. Therefore, any differences in the coefficients will be captured by the dummies on the intercepts, *i.e.* by the computer dummies. As a consequence, the estimated effects of computer use will be biased due to a misspecification of the functional form. To avoid this undesirable outcome, we will estimate the following equation:

$$Science_i = \sum_{j=1}^{5} D_{ij} \beta_j' X_i + \sum_{j=1}^{5} \delta_j D_{ij} + \sum_{j=1}^{5} D_{ij} \mu_j \hat{\nu}_i + \eta_i \quad i = 1, \ldots. N;\ j = 1, \ldots. 5 \qquad [2'']$$

which allows for the coefficients of X_i to vary across frequencies of computer use.

2.1. Computer use by location

The PISA 2006 survey includes questions about the location of student computer use. The survey asks students to rate their frequency of computer use at three locations: home, school, and other places. We can test whether computer use has different effects at home and at school by rewriting equation [2"] as follows:

$$Science_i = \sum_{j=1}^{5} D_{ij} \beta_j' X_i + \sum_{j=1}^{5} \delta_j^h D_{ij}^h + \sum_{j=1}^{5} \delta_j^s D_{ij}^s + \sum_{j=1}^{5} \delta_j D_{ij} + \sum_{j=1}^{5} D_{ij}\, \mu_j \hat{\nu}_i + \eta_i$$
$$i = 1, \ldots. N;\ j = 1, \ldots. 5 \qquad [2''']$$

where *s* and *h* denote at school and at home, respectively, the *D*'s are dummies for the frequency of computer use and the effects of computer use on science scores are captured by the δ's.

2.2. PISA plausible values

For each test and each student, PISA reports five plausible values. None of these values is the actual score of a student but they represent five random values drawn from the

posterior distributions of the students' scores (OECD, 2005). This implies that, in order to obtain unbiased estimates, we had to run the same regression model five times, once for each plausible value of the science scores, and compute the unbiased estimates and their standard based on these five sets of estimates. However, the estimates generated by the five regressions and their standard errors turned out to be almost identical. For the sake of simplicity, we have reported only the estimates for the first plausible value.

2.3. PISA replicate weights

As many international educational surveys, PISA 2006 uses a two-stage sample design. As a result, sampling variances have to be estimated through replication methods. These methods function by generating several subsamples, or replicate samples, from the whole sample. The statistic of interest is then estimated for each of these replicate samples and then compared with the whole sample estimate to provide an estimate of the sampling variance.

A replicate sample is formed simply through a transformation of the full sample weights according to an algorithm specific to the replication method. PISA 2006 uses the Fay variant of the Balanced Repeated Replication with a Fay coefficient equal to 0.5 and 80 replicates. This means that each regression was run 81 times, first by weighting the data with the student final weights and then by weighting the data with each of the 80 replicates.

3. What explains ICT use?

The first step of our analysis is to estimate the frequency of computer use as a function of the observable characteristics of students (*selection*). The PISA 2006 surveys contain several variables that can be used as a proxy for the characteristics of the students, their families and their schools. We used these indicators to explain the determinants of computer use at home and at school. We did not consider computer use in other places both because it represents a fairly small percentage, particularly in OECD countries, and because this type of use is likely to be more diverse than at home and at school and less related to education.

We estimated the same econometric model (Ordered Probit, equation [3] in Section 2) in each of the 33 countries – 26 OECD and 7 partner countries – who filled out the ICT survey.

We began with including all variables available in the PISA survey and that could be related to determinants of computer use based on previous studies: gender, immigration, computer possession, family wealth, educational attainment of the parents, etc. Then, we dropped variables that were not statistically significant one at a time, starting with the least significant. The final results are reported in Table 1.

Three variables turn out to have a significant impact in a large majority of countries. The first variable is **gender**: male students use computers more frequently than female students in 24 countries. In the remaining countries, we found no difference in the frequency of computer use between males and females.

The second variable is the level of **family wealth**. This variable is measured by an index (WEALTH) based on the possession of cellular phones, televisions, cars, and other country-specific items (Table 1). Previous studies have shown that household possessions are a more reliable indicator of family wealth than income.

In all countries, the wealth index has a positive sign: the higher the wealth of the student's family, the more he would tend to use a computer. In most countries, however,

Table 1. **Determinants of computer use**

	WEALTH	WEALTH2	HOMEPOS	HEDRES	PARED	HISEI	PARSCI	WHITEBLUE	IMMIGRATION	GENDER	SCHSIZE* 100	SCMATEDU	RATCOMP	F	Number of observations	Population size
Australia	**0.223**		**0.323**			**0.005**			**0.316**		**0.018**			**76.40**	12 362	207 458
	0.038		0.045			0.001			0.043		0.005					
Austria	**0.096**		**0.266**		**0.023**	**0.006**			**0.636**	**0.199**			*0.388*	**33.51**	4 287	78 227
	0.055		0.057		0.010	0.002			0.092	0.067			0.149			
Belgium	**0.499**	**–0.104**		**0.204**						**0.192**	**0.001**		**–0.043**	**127.01**	7 513	102 189
	0.035	0.021		0.024						0.040	0.000		0.004			
Canada	**0.431**			**0.161**	**0.031**	**0.004**			**0.319**	**0.177**			**0.972**	**38.57**	16 802	271 805
	0.040			0.024	0.010	0.001			0.060	0.038			0.172			
Chile	**0.638**	**0.096**	**0.305**		***0.020***								**3.260**	**272.73**	3 511	154 553
	0.079	0.025	0.061		0.009								1.040			
Czech Republic	**0.392**			**0.413**			**0.182**			**0.450**				**89.42**	4 695	96 765
	0.042			0.034			0.075			0.057						
Denmark																
Finland	**0.392**			**0.167**						**0.357**	***0.031***			**52.70**	4 163	54 046
	0.034			0.027						0.048	0.015					
Germany	**0.431**			**0.191**		*0.004*		***0.163***	**0.359**	**0.481**		*0.045*		**65.26**	3 738	687 142
	0.037			0.026		0.002		0.074	0.068	0.045		0.026				
Greece	**0.381**	***–0.048***	0.107						**0.231**	**0.489**			***0.511***	**83.60**	4 129	80 691
	0.052	0.023	0.049						0.065	0.042			0.261			
Hungary	**0.205**		**0.325**					***0.128***		**0.301**			**0.722**	**81.66**	3 955	92 655
	0.063		0.059					0.051		0.051			0.150			
Ireland	**0.243**		**0.232**			**0.006**								**102.85**	2 967	35 390
	0.059		0.052			0.001										
Iceland	**0.277**									**0.429**	***–0.047***			**19.98**	3 367	4 103
	0.048									0.068	0.000					
Italy	***0.112***	**–0.078**	**0.237**							**0.407**				**139.42**	18 133	422 440
	0.051	0.020	0.046							0.035						
Japan			**0.114**	**0.182**	**0.034**					***0.100***				**300.40**	4 272	794 391
			0.027	0.020	0.010					0.043						
Netherlands	**0.504**	**–0.168**						***0.193***			***0.013***			**20.74**	4 102	159 459
	0.078	0.046						0.096			0.006					
New Zealand	**0.347**			**0.139**				***0.140***	**0.312**	**0.129**				**37.14**	3 708	41 272
	0.032			0.031				0.069	0.065	0.047						
Norway	**0.235**	***–0.059***	***0.135***					***0.245***		**0.304**			**0.911**	**20.48**	3 554	44 618
	0.073	0.029	0.060					0.096		0.060			0.345			
Poland	**0.232**		**0.485**		***0.031***			*0.088*		**0.410**			**–0.492**	**171.46**	4 772	441 308
	0.061		0.053		0.013			0.049		0.039						

Table 1. **Determinants of computer use** *(cont.)*

	WEALTH	WEALTH2	HOMEPOS	HEDRES	PARED	HISEI	PARSCI	WHITEBLUE	IMMIGRATION	GENDER	SCHSIZE* 100	SCMATEDU	RATCOMP	F	Number of observations	Population size
Portugal	**0.290**	**–0.084**	**0.244**							**0.211**	**0.016**		***1.269***	**100.34**	4 374	77 248
	0.064	0.024	0.058							0.050	0.005		0.582			
Slovak Republic	**0.207**		**0.318**					**0.119**		**0.436**				**104.8**	4 190	66 979
	0.059		0.056					0.050		0.048						
Slovenia	0.406	–0.103				0.007			0.486	0.339						
	0.035	0.023				0.002			0.104	0.046						
Spain	**0.442**			**0.327**						**0.185**	**0.232**	**0.053**		**166.08**	16 134	313 251
	0.024			0.019						0.041	0.009	0.019				
Sweden	**0.385**	**–0.105**		**0.136**						**0.397**				**42.85**	3 457	99 169
	0.056	0.035		0.046						0.064						
Switzerland	**0.448**	**–0.067**		**0.101**				**0.151**	**0.320**	**0.181**				**82.24**	10 197	73 057
	0.025	0.023		0.020				0.049	0.061	0.036						
Turkey	**0.932**	**0.154**	***0.099***						**0.823**	*0.123*			**3.043**	**61.97**	2 833	376 773
	0.092	0.022	0.048						0.237	0.067			1.138			
Bulgaria	**0.484**		**0.338**	**0.025**		**0.006**				**0.225**	**0.023**			**80.93**	3 529	57 394
	0.071		0.059	0.011		0.002				0.058	0.009					
Croatia			**0.441**							**0.422**			**1.783**	**127.96**	4 162	37 112
			0.031							0.049			0.704			
Latvia	**0.447**		**0.305**								**0.037**	**0.109**		**115.79**	3 956	24 308
	0.090		0.083								0.010	0.040				
Lituania	**0.572**		**0.168**			**0.007**				**0.400**	**0.027**		**1.989**	**101.46**	4 130	44 047
	0.075		0.063			0.002				0.049	0.009		0.754			
Macao, China	**0.234**		**0.175**							**0.309**				**69.33**	4 206	5 641
	0.061		0.059							0.052						
Serbia	**0.363**		**0.241**			**0.009**				**0.312**				**163.16**	4 018	61 788
	0.066		0.054			0.001				0.042						
Thailand	**0.202**		**0.264**		**0.023**	**0.006**				**0.114**			**1.352**	**56.14**	4 984	509 641
	0.045		0.051		0.006	0.002				0.049			0.476			

Note: Standard errors below (white rows). All estimates significant at 1% except: ***significant at 5%***; *significant at 10%*; <blank>: not significant.

this effect is not monotonic and tends to decrease for high-income families (WEALTH squared has a negative sign). Only in Turkey and Chile does the positive effect of wealth seem to be stronger for high-income families.

The third factor explaining the frequency of computer use is the level of **education and cultural resources available at home**. These variables are also measured by two indexes. The index of educational resources (HEDRES) is composed of various school-related items such as the availability of a room for studying, a calculator, books, a computer for school work and educational software (Table 2). The index of home possessions (HOMEPOS) includes all items of the wealth index and the educational resources index (except for the item "school-dedicated computer at home") plus further cultural resources, *e.g.* books of poetry and classic literature, works of art. The sign of these two indexes is always positive: more educational and/or cultural resources tend to result in higher computer use.

Table 2. **Items included in PISA indexes: WEALTH, HEDRES and HOMEPOS**

		Item is used to measure index			
		WEALTH	HEDRES	HOMEPOS	CULTEDU
Q13	In your home, do you have?				
ST13Q01	A desk to study at		X	X	X
ST13Q02	A room of your own	X		X	
ST13Q03	A quiet place to study		X	X	X
ST13Q04	A computer you can use for school work		X		
ST13Q05	Educational software		X	X	X
ST13Q06	A link to the Internet	X		X	
ST13Q07	Your own calculator		X	X	X
ST13Q08	Classic literature (*e.g.* Shakespeare)			X	X
ST13Q09	Books of poetry			X	X
ST13Q10	Works of art (*e.g.* paintings)			X	X
ST13Q11	Books to help with your school work		X	X	X
ST13Q12	A dictionary		X	X	X
ST13Q13	A dishwasher (country-specific)	X		X	
ST13Q14	A <DVD or VCR> player (country-specific)	X		X	
ST13Q15	<Country-specific wealth item 1>	X		X	
ST13Q16	<Country-specific wealth item 2>	X		X	
ST13Q17	<Country-specific wealth item 3>	X		X	
Q14	How many of these are there at your home?				
ST14Q01	Cellular phones	X		X	
ST14Q02	Televisions	X		X	
ST14Q03	Computers	X		X	
ST14Q04	Cars	X		X	
Q15	How many books are there in your home?			X	X

Other factors turn out to have a positive effect on the frequency of computer use in a significant number of countries (the sign of the effect in brackets):

Parents' characteristics:

- their highest level of education (+);
- whether one of the parents has a science related degree (+);
- whether one of the parents is a white collar worker (+);

Student's characteristics:

- whether s/he is a first or second generation immigrant (+);

School characteristics:

- the number of teachers per student (+);
- the quality of educational resources (+);
- the size of the school (+);

ICT access in school:

- the number of computers per student at school (+).

4. What explains student performance?

The second step of the analysis is to estimate the returns from computer use (*outcomes*), controlling for observable and unobservable student's characteristics. Observable characteristics are proxied by a set of PISA variables measuring household wealth, parents' education, school characteristics and student's skills and attitudes. Unobserved students' characteristics are controlled for through the generalised residuals estimated from the selection equation (see Section 2 above for more details).

As discussed, we will focus on the student performance in science. Nonetheless, the scores of all PISA tests are highly correlated, so that the results presented for science provide information also about maths and reading.

We estimated the same statistical model (OLS, equation [2"] in Section 2) to explain science scores in each of the 33 countries – 26 OECD and 7 partner countries – that filled out both the general PISA survey and the ICT module. We began with including all variables available in PISA and that, based on previous studies, could be related to determinants of science performance. In addition, we included the frequency of computer use and the measure of unobserved students' characteristics (generalised residuals) estimated in the previous section. We also allowed for the estimated coefficients to vary across computer use frequencies (see Section 2 for more details).

In addition to students' characteristics, the educational literature stresses the importance of peer and contextual effects. These are commonly proxied by school-average of students' performances. In the econometric analysis, however, these variables raise an issue of endogeneity: to the extent students or their parents can choose their school, one would expect better students/wealthier parents to choose a school with higher average performances. Unfortunately, a selection model that tried to address the endogeneity of both school and ICT use would become unmanageable. In order to minimise the endogeneity issue due to potential school selection, our analysis includes a set of school-level variables which are not computed based on students' performances and are less likely to be endogenous: school size, principal evaluation, and the number of teachers per student.

The final results are reported in Table 3, while the estimated coefficients on the computer use dummies are reported in Table 4. In most countries, the variables that affect PISA science scores are the following:

Students' characteristics:

- gender;
- immigration status;
- interest in science;
- motivation to continue learning about science.

Parents' characteristics:

- science-related career;
- educational attainment;
- occupation.

Household characteristics:

- home possession;
- educational and cultural resources;
- number of books at home.

School characteristics:

- size of the school;
- quality of educational resources.

Frequency of computer use:

- frequency of computer use in any location;
- frequency of computer use at school and at home.

The first set of factors is related to students' characteristics. The variable **gender** measures the difference in science scores between males and females. The variable has a positive sign, showing that males tend to have higher scores than females, when controlling for all other differences. The difference in science scores between males and females ranges between 18 points in Chile and 6 points in Norway. Iceland is the only country where science scores are higher for female students (9 points).

The variable **immigration** measures the difference in science scores between "immigrants" and natives. Its sign is negative in most countries and indicates that first and second generation immigrants tend to have lower science scores than natives. Immigration appears as one of the main determinants of the observed differences in science scores. It explains over 90 points in Finland, 70 points in Austria and Iceland, 60 points in Belgium and Thailand, and about 50 points in Denmark, Germany, the Netherlands, Sweden and Switzerland. In most of the remaining countries, the effect of this variable is between 20 and 30 points. The differences due to immigration are the lowest in Australia (about 10 points) while Macao (China) and Serbia are the only countries where immigrants have higher science scores than natives (13 and 12 points, respectively).

Table 3. **Determinants of science scores**

	GENDER	IMMIGRATION	WEALTH	CULTEDU	HISEI	WHITEBLUE	PARED	PARSCI	INTSCIE	SCIEFUT	BOOKS	SCHSIZE* 100	SCMATEDU	SLOPE DUMMIES	F	R^2	Number of observations	Population size
Australia		**–9.79**	**–7.51**	**16.53**	**0.86**	***7.74***	**2.91**		**10.62**	**18.03**	**29.48**	**0.96**	**6.12**	No	**267.10**	0.26	12 226	205 258
		3.47	1.84	2.08	0.08	3.64	0.54		1.16	1.13	2.03	0.37	1.58					
Austria	**9.50**	**–74.52**		**16.20**	**0.74**				**14.91**	**7.42**	**36.93**	**4.44**		No	**81.92**	0.35	4 269	77 888
	3.80	7.94		3.79	0.10				2.13	2.03	3.74	0.98						
Belgium		**–61.36**		**20.69**	**1.04**			***6.08***	**13.99**	**13.59**	**16.10**	**–0.07**		**Yes**	**137.83**	0.31	7 405	100 696
		5.47		3.87	0.09			2.58	2.04	1.44	2.72	0.02						
Canada	**8.87**	**–21.43**	**–8.05**	**7.31**	**0.98**		***1.30***	**7.35**	**9.80**	**16.33**	**30.86**	**0.98**		No	**126.28**	0.21	16 698	270 319
	1.84	3.60	1.95	2.85	0.07		0.55	2.67	1.48	1.15	2.60	0.30						
Chile	**18.40**	***–32.63***	*–7.36*	**16.48**	**0.78**		**2.46**	***11.16***	**4.49**	**5.94**	**20.88**		**10.30**	No	**38.35**	0.26	3 446	151 631
	3.36	15.79	4.21	3.86	0.13		0.50	5.02	1.60	1.67	4.71		3.52					
Czech Republic	**10.23**	**–38.48**	***–6.44***	**28.34**	**1.62**				**14.10**		**29.33**	**3.47**		No	**68.20**	0.24	4 652	95 716
	3.75	11.40	3.26	5.61	0.14				1.82		4.44	0.00						
Denmark	**11.05**	**–54.59**		**28.95**	**0.80**		**2.39**			**19.15**				No	**68.93**	0.22	2 754	34 211
	2.93	8.80		2.46	0.12		0.81			1.66								
Finland	**8.14**	**–90.90**	**–5.60**	**9.55**	**0.55**		**1.79**		**17.68**	**16.10**	**26.60**			**Yes**	**114.84**	0.24	4 122	53 503
	2.69	16.87	2.06	3.95	0.09		0.55		1.83	1.75	2.81							
Germany	**8.03**	**–52.96**	**–5.02**	**15.29**	**0.71**		**2.75**	**11.78**	**16.28**	**7.64**	**27.96**	**4.07**		No	**80.18**	0.32	3 690	677 466
	2.70	6.18	2.11	3.67	0.09		0.47	3.05	2.11	1.56	3.18	0.83						
Greece		**–32.60**	**–10.11**	**40.60**	**0.79**		**3.15**	***8.67***	**19.08**				***7.02***	**Yes**	**49.18**	0.26	4 112	80 342
		8.40	2.22	3.71	0.12		0.58	3.56	1.80				3.06					
Hungary	**15.59**		**–3.85**	**45.22**	**0.78**		**6.36**	***6.58***	**13.13**		**16.83**			No	**76.66**	0.32	3 947	92 467
	2.60		1.84	4.60	0.13		0.71	2.98	1.99		3.37							
Ireland	**11.86**		**–7.63**	**15.88**	**0.75**		***1.70***		**12.67**	**15.44**	**31.02**		***7.63***	No	**68.79**	0.26	2 950	35 177
	3.73		2.43	4.08	0.11		0.71		1.89	1.93	4.07		3.32					
Iceland	**–8.74**	**–72.19**	**–16.90**	**18.19**	**0.68**		**3.53**		**13.18**	**17.32**	**22.31**	**–4.33**	**3.68**	No	**94.88**	0.26	3 323	4 050
	2.66	12.76	2.22	4.12	0.10		0.53		1.97	2.29	3.54	0.74	1.46					
Italy		**–29.11**	**–6.74**	**29.90**	**0.91**				**15.22**		**22.79**	**2.40**		***Yes***	**65.26**	0.19	17 712	412 609
		5.85	2.32	4.27	0.08				1.30		2.82	0.49						
Japan				**29.21**			**8.07**		**19.90**	**12.99**		**3.76**			**354.79**	0.24	4 272	794 391
				3.93			0.85		1.69	2.00		0.76						
Netherlands	**8.72**	**–47.26**	***–5.56***	**21.30**	**1.20**			**9.36**	**14.76**	**8.67**	**20.05**	**3.17**		No	**130.43**	0.33	3 978	154 597
	2.92	6.80	2.40	3.56	0.11			3.02	1.79	1.83	3.50	0.64						
New Zealand		**–23.94**	**8.41**	***9.47***	**1.19**		**2.68**		**12.26**	**18.19**	**38.37**	**0.92**	***4.77***	No	**150.44**	0.27	3 686	41 060
		4.35	2.24	3.94	0.11		0.79		1.97	2.03	3.76	0.26	2.21					
Norway	*5.65*	**–33.47**	**–11.37**	**15.94**	**0.92**			***6.08***	**20.37**	***4.82***	**26.90**			No	**95.31**	0.22	3 499	43 927
	3.14	7.57	2.00	3.76	0.10			2.78	1.57	2.02	3.98							
Poland	**5.87**			**35.49**	**0.62**		**7.36**		**12.83**		**16.21**	***0.20***		No	**72.04**	0.20	4 751	439 445
	2.33			3.25	0.11		0.89		1.76		3.01	0.09						

Table 3. **Determinants of science scores** *(cont.)*

	GENDER	IMMIGRATION	WEALTH	CULTEDU	HISEI	WHITEBLUE	PARED	PARSCI	INTSCIE	SCIEFUT	BOOKS	SCHSIZE* 100	SCMATEDU	SLOPE DUMMIES	F	R^2	Number of observations	Population size
Portugal	**6.54**	**–36.27**	**5.98**	**25.53**	**1.15**			**12.71**	**7.82**	**16.39**	***7.75***	**4.02**		***Yes***	**93.97**	0.29	4 320	76 219
	2.39	7.22	2.14	4.09	0.09			3.95	2.14	1.55	3.48	0.65						
Slovak Republic	***6.21***		**–5.19**	**37.01**	**0.86**	**14.08**	**3.64**	**10.62**	**13.28**	**20.32**	**2.37**			No	**49.32**	0.25	4 178	66 785
	3.16		1.97	4.64	0.13	4.01	0.81	3.64	1.55	3.18	1.14							
Slovenia	**9.42**	**–30.33**	**–8.43**	**30.08**	**0.92**		**3.69**		**11.67**	**9.11**	**19.49**	**8.25**		No	**130.98**	0.34	5 535	18 114
	2.34	4.96	1.75	3.30	0.12		0.77		1.86	1.57	3.87	0.43						
Spain	**10.40**	**–34.28**	**–12.61**	**22.89**	**0.80**		**1.82**		**10.52**	**12.26**	**22.56**			No	**174.07**	0.25	15 931	308 851
	2.17	5.80	1.53	3.29	0.08		0.35		1.19	1.23	2.50							
Sweden		**–48.83**			**1.15**				**20.03**		**33.29**	***2.52***		***Yes***	**104.08**	0.27	3 407	97 845
		4.67			0.08				2.06		3.38	1.19						
Switzerland	**7.01**	**–56.14**	**–7.10**	**11.02**	**0.85**		**2.89**		**20.97**	**9.75**	**28.48**	**1.66**	**7.97**	No	**160.95**	0.36	10 124	75 522
	2.28	3.16	1.59	3.27	0.09		0.49		1.55	1.43	2.85	0.50	2.16					
Turkey			**8.94**	**33.34**	**0.84**		**3.99**		**14.91**					No	**17.97**	0.26	2 893	384 596
			2.28	4.48	0.14		0.73		1.71									
Bulgaria	***9.19***		**–5.84**	**50.28**			**2.10**	***9.89***	**7.66**		**19.26**	**7.16**		No	**33.31**	0.33	3 514	57 077
	3.83		2.54	5.38			0.81	4.23	1.77		4.08	1.11						
Croatia	***6.93***				**0.88**	**10.93**		**8.94**			**13.03**	**3.22**		No	**52.28**	0.22	4 144	36 950
	3.09				0.11	3.55		2.93			3.69	0.01						
Latvia					**0.93**						**16.67**			No	**71.69**	0.15	3 940	24 218
					0.13						3.21							
Lithuania				**46.04**	**0.81**			**8.33**	**16.77**		**18.73**		***7.04***	No	**50.28**	0.23	4 109	43 825
				4.45	0.10			3.39	1.99		2.98		3.40					
Macao, China		**13.11**	**–8.07**	**28.96**	**0.39**		***1.03***		**19.65**			**–0.39**	**9.79**	No	**60.47**	0.16	4 148	5 558
		2.66	2.39	3.21	0.11		0.49		1.65			0.10	1.42					
Serbia		**11.91**		**39.24**	**0.95**	**10.59**		**10.34**	**7.96**		**12.39**	*1.24*		No	**38.50**	0.18	3 932	60 462
		4.41		3.81	0.11	3.80		3.52	1.78		3.56	0.01						
Thailand		**–61.58**	**6.20**		**0.47**			**26.84**	**16.21**		***8.21***	**1.12**	**6.60**	No	**97.74**	0.26	4 830	494 153
		22.46	1.96		0.10			6.83	1.70		3.57	0.27	2.23					

Note: Standard errors below (white rows). All estimates significant at 1% except: ***significant at 5%***; *significant at 10%*; <blank>: not significant.

Table 4. **Increase in science scores from computer use**

	Never	Once a month or less	A few times a month	Once or twice a week	Almost every day	Selection
Australia	**389.51**			**18.45**	**35.94**	No
	10.36			7.46	7.16	
Austria	**356.77**				**19.13**	No
	11.11				3.21	
Belgium	**368.91**			**27.36**	**35.02**	No
	9.56			6.46	5.52	
Canada	**398.85**			**16.91**	**23.33**	No
	9.59			5.82	5.17	
Chile	**319.17**				**50.64**	**Yes**
	17.03				11.07	
Czech Republic	**301.03**			**41.54**	**69.80**	**Yes**
	22.50			8.90	15.10	
Denmark	**378.41**					No
	11.52					
Finland	**402.29**					No
	16.08					
Germany	**354.74**				**12.80**	No
	11.62				2.69	
Greece	**349.56**					No
	12.04					
Hungary	**273.61**			**30.81**	**39.20**	No
	16.32			11.14	10.53	
Ireland	**389.93**				**9.00**	No
	18.20				3.29	
Iceland	**347.66**				**17.14**	
	15.43				4.62	
Italy	**363.01**			*15.94*	**36.65**	**Yes**
	9.32			9.33	8.33	
Japan	**411.85**				**11.24**	**No**
	11.88				3.67	
Korea						
Netherlands	**372.20**			*23.93*	**34.70**	*Yes*
	19.06			14.23	13.65	
New Zealand	**392.09**				***7.15***	No
	12.77				3.68	
Norway	**366.19**			**40.28**	**41.25**	No
	10.22			9.93	8.39	
Poland	**337.17**				**10.75**	No
	10.81				3.27	
Portugal	**318.17**			**22.70**	**39.30**	No
	10.62			7.10	8.40	
Slovak Republic	**331.17**			***9.05***	**25.03**	No
	12.97			4.54	4.83	
Slovenia	**326.25**			*12.51*	**20.52**	No
	11.47			7.60	7.43	
Spain	**353.84**		***12.84***	**25.73**	**38.11**	No
	7.50		5.78	5.02	5.23	
Sweden	**381.17**				**24.54**	**Yes**
	11.82				7.99	
Switzerland	**349.44**			***14.25***	**17.85**	No
	10.10			6.21	6.16	
Turkey	**338.06**					No
	13.77					

Table 4. **Increase in science scores from computer use** *(cont.)*

	Never	Once a month or less	A few times a month	Once or twice a week	Almost every day	Selection
Bulgaria	**305.90**				**16.59**	No
	13.19				4.40	
Croatia	**376.67**		**28.81**	**30.54**	**43.09**	**No**
	10.71		8.98	7.73	7.42	
Latvia	**396.72**			**19.25**	**26.29**	No
	8.14			5.59	5.43	
Lithuania	**395.55**			**22.97**	**35.96**	No
	8.15			5.11	5.20	
Macao, China	**401.92**			***20.88***	**39.88**	No
	13.12			11.92	11.97	
Serbia	**360.92**			***22.47***	**31.69**	No
	13.16			9.29	8.61	
Thailand	**310.02**			*7.96*	**12.51**	No
	23.29			4.73	4.91	

Note: Standard errors below (white rows). All estimates significant at 1% except: ***significant at 5%***; *significant at 10%*; <blank>: not significant.

The 2006 PISA dataset has nine science indexes related to students' attitudes and perceptions of science. Two of these indexes were significant and positive: the first measures students' **interest in science** (INTSCIE); the second students' motivation to continue learning about science or pursuing a **science-related career** in the future (*SCIEFUT*).[1] In most countries, a 1-point increase in both indexes accounts for between 20 and 30 points of the observed differences in science scores. Therefore, students with a stronger interest in science will tend to have better scores in science.

The second set of variables is related to the characteristics of parents. **Parental education** is often used in the analysis of educational outcomes. It is measured by the highest number of years in education of either parent (PARED).[2] Our findings show that the longer the time parents spent in education, the higher the expected science scores of their children. The effect is the largest in Japan, where one additional year of either parent's education increases the science scores by over 8 points; Poland (7 points) and Hungary (6 points). It is the smallest in Canada and Macao, China (about 1 point).

Parents' occupations are classified according to the level and specialisation of the skills they required. The index (HISEI) is based on the International Standard Classification of Occupations (ISCO-88) and ranges between 16 and 90. We found out that the higher the skills content of the occupation of either parent, the higher the science scores of his/her children. The effect on science scores can be as large as 145 points in the Czech Republic, 108 points in the Netherlands and New Zealand, and over 100 points in Portugal and Sweden.

Finally, the index PARSCI measures whether either **parent has a science-related career**. Its positive sign indicates that students have better science scores if one of their parents has a science-related career. Its effect ranges between 6 points in Norway and Belgium and 27 points in Thailand.

The third set of variables measures household characteristics. Educational literature points out the important role of family wealth on students' performances. The effects of wealth, however, are ambiguous. On the one hand, higher wealth may provide for more educational and cultural resources, which have a positive impact on students' scores. On

the others, higher wealth may weaken students' incentives to learn and may reduce the cost of leisure relative to education.

In our model, these two opposite effects are captured by two variables. The first variable is the level of **family wealth**. This variable is measured by an index (WEALTH) based on the possession of cellular phones, televisions, cars, and other country-specific items (Table 2). Previous studies have shown that household possessions are a more reliable indicator of family wealth than income.

The second variable is the index of **cultural and educational possession** (CULTEDU), which includes a set of educational resources, *e.g.* the availability of a room for studying, a calculator, books, educational software; and a set of cultural resources, *e.g.* books of poetry and classic literature, works of art (Table 2). The index, which is not available in PISA, has been estimated as the variation in the home possession index (HOMEPOS) that is not correlated to the wealth index (WEALTH).[3]

Our regression results show that the effect of cultural and educational possession is always significant and positive while the effect of family wealth, when significant, is negative. The negative sign of the wealth index captures the negative effect of wealth on the students' incentives to learn while the positive impact of the home possession index captures the positive effect of educational and cultural resources on students' performance.

The effects of cultural and educational resources at home on sciences scores tend to be large. In Bulgaria, a 1-point increase in home possession would result in a 50-point increase in science scores. The increase is over 45 points in Hungary and Lithuania, no less than 35 points in Greece, Poland, Serbia and the Slovak Republic and just below 30 points in the Czech Republic, Denmark, Italy, Japan, Macao (China) and Slovenia.[4]

PISA 2006 also reports interesting information about the **number of books** in a household. We found that students from households with a large number of books (over 100) tend to achieve better scores in science. The role of this factor appears even stronger when one considers that the number of books also enters the home possession index.

The last set of variables looks at the characteristics of the school. The **size of school** (SCHSIZE) turned out to have a significant and positive impact on science scores in most countries. A positive effect may be an indication that large schools are proportionally better endowed with physical and human resources – *e.g.* schools in urban *versus* rural areas – or it may be due to some "economy of scale" in the use of educational resources as not all students use libraries, laboratories, tutors, etc., at the same time, students in larger schools would benefit more from the same stock of educational resources per capita.

This effect is fairly large: an increase in the school size by 100 students would result in an increase in science scores by 8 points in Slovenia, 7 in Bulgaria, and over 4 in Austria, Germany and Portugal. A negative impact of the size of school was found only in Iceland.

The **quality of educational resources** (SCMATEDU) is based on the self-evaluation of the school principal and provides a further measure of educational resources at school.[5] It has a positive and significant effect: a 1-point increase in the index of educational resources would increase science scores by 10 points in Chile and Macao (China) and by over 7 points in Greece, Ireland, Switzerland and Lithuania.

5. Does ICT use improve student performance?

The final set of variables consists of dummies for the frequency of computer use. We first ask whether higher frequencies of computer use are associated with higher science scores, independently of whether the computer is used at school, at home or in both locations. We then consider whether the effects of computer use differ across locations.

Table 4 shows that higher frequency of computer use is associated with higher science scores in all countries. In a large majority of them, this effect becomes significant when the computer is used "once or twice a week" or "almost every day". Spain and Croatia are the only countries where using a computer "a few times a month" seems to have a significant effect on science scores.

The educational returns from using a computer "once or twice times a week" appears the largest in the Czech Republic and Norway: the science scores of students using a computer "once or twice a week" are 40 points higher than those of students with a lower frequency of computer use. In Hungary and Croatia this effect is 30 points while in most of the remaining countries it is about 20 points. Thailand and the Slovak Republic show the lowest increase from using a computer "once or twice a week" (7 and 9 points, respectively).

The educational returns from using a computer "almost every day" turn out to be the largest in the Czech Republic and Chile: the science scores of students using a computer "almost every day" are, respectively, 70 and 51 points higher than those of students using a computer "once or twice a week". The difference is about 40 points in Hungary, Norway, Portugal, Croatia and Macao (China) and no less than 35 points in Australia, Belgium, Italy, the Netherlands, Spain, and Lithuania. The lowest effect is found in New Zealand (7 points), Ireland (9 points) and Poland (10 points).

In brief, our results suggest that computer use does have a positive and significant effect on science scores.

One related question is whether the effects of ICT on student performance are different when ICT is used at home or at school. On the one hand, we may expect ICT use at school to be accompanied by some ICT training, to be more closely related to educational activities and to benefit from the expertise of a teacher (Wenglinsky, 2002). On the contrary, ICT use at home may be more related to leisure activities and does not benefit from any formal training (Fuchs and Woessmann, 2004).

On the other hand, students using computer at home are likely to be more interested in ICTs, have more scope for experiment and self-learning and can search and discover the resources – both in terms of software and web content – that are best suited to their needs (Ravitz, Mergendoller and Rush, 2002; Valentine *et al.*, 2005; OECD, 2006).

We can further develop our analysis to explore this question. We have found that higher frequency in computer use is associated with higher science scores. We can now distinguish whether computer use occurs at school or at home and test whether the effects on science scores vary with location.

As a same student may use computer both at home and at school, the location of computer use is defined according to the location of the highest frequency of use. For example, if a student uses the computer once a week at home and almost every day at school, he would be considered as using the computer at school.

There are cases, however, when a student uses a computer at home and at school with the same frequency. In such circumstances it is not possible to make a distinction between

home and school: the effects would depend on whether the use is closer to the "school use" or the "home use".

Table 5 shows the estimated increase in average science scores associated with computer use at home and at school. Two results are worth highlighting. First, in a large majority of countries, computer use at school has no significant effect on science scores. Therefore, the above findings that computer use is associated with higher science scores seems to be entirely driven by computer use at home only. This is notably the case in Belgium, Finland, Germany, Greece, New Zealand, Poland, Switzerland, Bulgaria, Croatia and Latvia.

Table 5. **Increase in science scores from computer use at home and at school**

	Never	A few times a month			Once or twice a week			Almost every day			Selection
		School and home	School	Home	School and home	School	Home	School and home	School	Home	
Australia	**388.79**				**20.40**		**27.17**	**39.71**	**26.43**	**38.23**	No
	8.11				5.33		5.31	4.79	5.74	4.34	
Austria	**355.68**							**32.44**	**19.38**	**16.17**	No
	10.93							5.63	7.24	3.34	
Belgium	**383.42**				**20.35**					**42.26**	**Yes**
	7.01				4.53					5.25	
Canada	**405.37**						**18.68**	**15.43**		**20.25**	
	9.64						5.53	4.51		3.73	
Chile	**319.32**								***24.45***	**50.54**	**Yes**
	17.21								11.75	7.95	
Czech Republic	**301.03**				**41.54**	**41.54**	**41.54**	**69.80**	**69.80**	**69.80**	**Yes**
	22.50				8.90	8.90	8.90	15.10	15.10	15.10	
Denmark										**7.81**	No
										3.77	
Finland	**402.29**						**15.82**			**18.37**	No
	16.08						5.57			4.41	
Germany	**353.35**									**15.52**	No
	11.77									3.09	
Greece	**349.56**						**26.01**			**34.25**	
	12.04						4.45			5.00	
Hungary	**273.91**				**36.80**	***23.75***	**34.83**	***27.89***	**34.22**	**41.57**	No
	16.24				11.80	11.37	12.59	12.13	12.39	10.64	
Ireland	**391.22**						***7.73***				No
	18.21						3.19				
Iceland	**349.51**							**17.33**			No
	14.72							3.79			
Italy	**364.57**				**23.32**	**4.37**	**23.32**	**37.53**	**13.78**	**37.53**	**Yes**
	9.29				9.12	1.05	9.12	8.25	3.09	8.25	
Japan	**412.85**									**13.70**	No
	11.92									3.76	
Korea											
Netherlands	**367.03**				***30.65***		**43.86**	***29.47***	***31.28***	**46.45**	***Yes***
	17.00				13.67		14.63	12.52	15.44	12.16	
New Zealand	**391.93**						***10.27***			**13.37**	No
	12.52						4.99			3.27	
Norway	**366.79**				***30.55***	***34.88***	**45.26**	**29.92**	**39.83**	**43.44**	No
	10.28				14.40	15.71	10.10	9.03	13.94	8.55	

Table 5. **Increase in science scores from computer use at home and at school** *(cont.)*

	Never	A few times a month			Once or twice a week			Almost every day			Selection
		School and home	School	Home	School and home	School	Home	School and home	School	Home	
Poland	**334.95**									**15.77**	No
	10.62									3.15	
Portugal	**326.78**				**21.37**		**20.55**	**19.85**		**34.39**	No
	10.22				6.25		7.33	7.57		6.53	
Slovak Republic	**331.75**				**17.00**		***13.81***	*21.32*		**27.43**	No
	11.71				5.15		5.95	11.94		3.31	
Slovenia	**326.25**				*12.51*	*12.51*	*12.51*	**20.52**	**20.52**	**20.52**	No
	11.47				7.60	7.60	7.60	7.43	7.43	7.43	
Spain	**353.30**			***12.96***	**20.83**	**20.83**	**31.12**	***20.49***	***20.49***	**39.13**	No
	7.39			5.77	5.58	5.58	11.36	9.56	9.56	15.29	
Sweden	**381.17**							**24.54**	**24.54**	**24.54**	**Yes**
	11.82							7.99	7.99	7.99	
Switzerland	**356.91**						*8.65*			**11.47**	No
	7.67						4.79			3.33	
Turkey	**338.06**							**–27.14**	**–27.14**	**2.87**	No
	13.77							6.67	6.67	0.66	
Bulgaria	**305.56**									**25.46**	No
	13.21									4.15	
Croatia	**391.67**	***26.77***		***22.62***	**21.96**		**22.28**			**30.13**	No
	9.51	12.50		10.23	5.18		7.29			4.17	
Latvia	**400.61**				**21.24**	***9.14***	**21.24**			**25.53**	No
	9.11				6.07	4.59	6.07			5.32	
Lithuania	**393.82**				**36.67**	**16.35**	**36.84**		***24.66***	**41.02**	No
	7.34				7.67	5.62	7.77		10.24	4.45	
Macao, China	**400.89**				**25.42**	**9.94**	**25.42**	**40.27**	**40.27**	**40.27**	No
	13.10				11.78	3.61	11.78	11.93	11.93	11.93	
Serbia	**363.95**				**39.45**	**25.68**	**41.76**			**44.09**	No
	10.43				8.41	7.26	11.74			6.48	
Thailand	**299.72**				**27.79**	**5.26**	**27.79**	**26.27**	**–2.70**	**26.27**	No
	22.69				5.78	1.05	5.78	4.92	–0.41	4.92	

Note: Standard errors below (white rows). All estimates significant at 1% except: ***significant at 5%***; *significant at 10%*; <blank>: not significant.

Second, when computer use at school does have an effect on science scores, this is smaller than the effect of computer use at home. In a number of countries this differential is very large. In Chile, Italy and Thailand, the increase in science scores is about 25 points higher when a computer is used "almost every day" at home rather than at school. This differential is 19 points in Spain, 16 points in Lithuania and 15 points in the Netherlands.

No significant differences between computer use at home and at school were found in the Czech Republic, Slovenia, Sweden and Macao, China. Austria is the only country where computer use at school has a larger effect on science scores than at home (3 points).

As for the effect of computer use "at home and at school", in most countries this seems smaller than the effect of computer use at home only. This suggests that the use of computer "at home and at school" is closer to the use at school than the use at home. There are, however, a few interesting exceptions where the effects on science scores are larger when a computer is used both at home and at school. This is the case of Australia and, even

more, Austria, where the effect of computer use "at home and at school" is significantly larger than the effect of computer use "at home" or "at school" separately.

To sum up, computer use seems to have a positive effect on science scores. However, this effect is mainly driven by the use of computer at home rather than at school.

6. Implications for educational policy

Our analysis has shown that computer use does increase student performance (science scores) in PISA. This result has been obtained after having controlled for observable (*spurious correlation*) and unobservable (*selection*) differences among students, their families and their schools. The estimated increase in science scores, however, seems to be due mainly to the use of computer at home whereas the effects of computer use at school seem smaller or inexistent.

This finding questions the effectiveness of educational policies aimed at promoting computer use at school as a tool for learning. Traditionally, these policies have focused on promoting ICT access and use at school but they have tended to neglect ICT access and use at home. If ICTs turn out to be more effective for educational purposes when they are used at home, educational policies should shift the mix of ICT access and use from school to home. Two measures appear suitable to achieve this objective.

The first is to promote ICT access at home, *e.g.* by providing students and their families with financial support for the purchase of a computer or for the subscription to the Internet. The second measure is to ensure closer complementarities between the use of computer at home and at school. In particular, to make sure that the self-learning and exploration which is characteristic of ICT use at home becomes integrated in the use of ICT at school. In this way, the potential opened up by ICT use at home may be fully exploited in the formal learning environment offered in school.

Whether these measures may deliver the expected results, is a question that the forthcoming PISA surveys may want to take on board.

Notes

1. The range of variation is between –3.15 and 3.29 for INTSCIE and –1.42 and 2.27 for SCIETFUT.
2. The index PARED varies between 0 and 18 years of education.
3. More formally, CULTEDU is the OLS residuals of the regression: $HOMEPOS = \beta_0 + \beta_1 WEALTH + \varepsilon$.
4. WEALTH and CULTEDU range between –4.40 and 3.30 and –2.88 and 2.21, respectively.
5. SCMATEDU ranges between –3.43 and 2.14.

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How Large Are Competitive Pressures in Services Markets? Estimation of Mark-ups for Selected OECD Countries

by
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Mark-ups can provide valuable information on competitive pressures in various sectors of the economy, reflecting pressures stemming from rules of conduct imposed by regulators as well as those arising from such factors as trade and FDI or increasing consumer demands in terms of price and quality. This study estimates mark-ups for services industries in European OECD members and its novelty is that it: i) *allows for non-constant returns to scale;* ii) *jointly estimates mark-ups for all sectors and in all countries; and* iii) *estimates mark-ups at a detailed level of sectoral disaggregation. The estimation is done for the period 1993-2006 and uses firm level data of the* Amadeus Database. *In general, the estimated mark-ups are higher for professional services, real estate, renting and utilities, while they tend to be substantially lower for construction, computer services, retail and wholesale trade and catering. There is also large variation across countries in terms of the sizes of the estimated mark-ups. Competitive pressures according to these mark-ups should be large in the United Kingdom and most Scandinavian countries, and relatively small in Central European countries, Sweden and Italy.*

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Mark-ups can provide valuable information on competitive pressures in various sectors of the economy, reflecting pressures stemming from rules of conduct imposed by regulators as well as those arising from such factors as increasing consumer demands in terms of price and quality. Trade and foreign direct investment (FDI) are also sources of such pressure. In particular, FDI can be important, as very often it is the only source of competitive pressure.

Developments in the theoretical and empirical literature over the past decades suggest a departure from the standard assumptions of neoclassical production theory with respect to perfect competition and constant returns to scale. This departure allows for the assumption of monopolistic firms charging mark-ups over marginal costs and opens up new avenues for the estimation of such mark-ups. Following Roeger (1995), the difference between the primal and the dual Solow residuals is explained as a result of imperfect competition, and by subtracting the two residuals from each other, the unobservable productivity term cancels out. This way, the price-cost margins can be estimated consistently by standard econometric techniques, though the results obtained are mark-ups over average cost and not marginal cost. The assumption of constant returns to scale may, however, be too restrictive as not all sectors in all countries may exhibit constant returns to scale. Following Dobrinsky *et al*. (2004), this assumption is relaxed and mark-ups are re-estimated for the sectors and countries for which the hypothesis of constant returns to scale was rejected.

The novelty of this paper is that it: *i)* allows for non-constant returns to scale when estimating mark-ups for a number of OECD countries; *ii)* jointly estimates mark-ups for all sectors and in all countries; *iii)* estimates mark-ups for services sectors at a conveniently detailed level of sectoral disaggregation; and *iv)* uses different estimates of input coefficients of the production function that feed into the estimation function of mark-ups to check for robustness of results. The estimation is done for the period 1993-2006 and is confined to European members of the OECD using the Amadeus data base.

In general, the estimated mark-ups are higher for professional services, real estate, renting and utilities, while they tend to be substantially lower for construction, computer services, retail and wholesale trade and catering. The mark-ups in other sectors such as transportation, and telecommunications are somewhere in between these two ends of the spectrum. There is also wide variation across countries in terms of the size of the estimated mark-ups. Competitive pressures according to these mark-ups should be large in the United Kingdom and most Scandinavian countries, and relatively small in Central European countries, Sweden and Italy. Spain, Germany and France are in between these two country groups.

To allow for comparison across a larger number of OECD countries, the analyses could be extended to non-European members using the *Orbis Database*. The methodology applied could also be further refined, for example, by using the Levinsohn-Petrin method to obtain the input coefficients of the production function. Also, in future analysis, competitive

pressures stemming from regulation could be delineated from other pressures stemming from other sources using the newly estimated mark-ups.

The most commonly used tool to assess competitive pressures in different markets is to compare mark-ups prevailing in those markets. Mark-ups can provide valuable information on competitive pressures in various sectors of the economy, reflecting pressures stemming from rules of conduct imposed by regulators as well as those arising from such factors as increasing consumer demands in terms of price and quality. Trade and foreign direct investment (FDI) are also sources of such pressure. In particular, FDI can be important as it is very often the only source of competitive pressure.

Mark-ups have some analytical advantages over approaches to assessment of competitive pressures that rely on concentration indices such as the Herfindahl-Hirsch Index. These indices may be misleading in that higher market shares are not necessarily associated with lower competitive pressure; by the same token, in fragmented markets with numerous small players there is not necessarily higher competitive pressure. Mark-ups, in turn, assess the effect of a number of sources of competitive pressure that may not be related to market structures.

Given the lack of available estimates of mark-ups in services industries for OECD countries, in particular at the detailed level of sectoral disaggregation and for a large number of countries, this paper proposes new estimates based on micro-data. This allows for estimation at a more detailed sectoral level so that estimates – for instance, for different professional services – can be obtained separately. An estimation at a disaggregated level also allows for testing: *i)* whether mark-ups are higher in services where customer-specific products prevail and markets are segmented such as legal services; *ii)* whether mark-ups are lower in services that are more traded such as computer services or business consultancy; *iii)* whether mark-ups are higher in services that require more human capital input such as engineering; and *iv)* whether mark-ups are higher in network industries owing to the large sunk and fixed costs these industries have to assume.

The paper is structured as follows: after setting the scene by highlighting the need to estimate mark-ups using firm-level data, the estimation method is described along with the data used and, finally, the estimates are compared across countries and sectors. A summary of the findings and possible further steps conclude the paper.

1. New estimates using firm-level data

There is an abundant literature on estimating mark-ups, but most studies are constrained to a particular country and to manufacturing industries. Very few studies cover several countries, let alone focus on OECD countries and include services industries. The study by Høj *et al.* (2007) is one of the few exceptions, estimating mark-ups using industry-level data for 17 OECD countries[1] over the 1975-2002 period. The coverage of services in that study, however, is limited to just six industries[2] and it does not include construction. In addition, the authors lump telecommunications with posts, wholesale trade with retail and provide only a single estimate for all business services and for all utilities.[3] Another study estimating mark-ups for service industries is by Christopoulou and Vermeulen (2008) for the 1981-2004 period.This estimation uses industry-level data and covers 50 sectors, including 27 service industries, but only 9 countries.[4] Bouis and Klein (2009) improve the methodology of Christopoulou and Vermeulen (2008) and provide mark-up estimates for 11 countries for 1993 to 2004.[5]

The use of firm-level data in the analysis that follows allows for a high-level of disaggregation of sectors and also for the exploitation of information in a manner that is not possible in the case of industry-level data. This way, mark-ups for sub-sectors such as, for instance, accounting services, water provision or telecommunications can be estimated, while industry-level data would not allow for the exploration of competitive pressures in these sectors. Thus, the interpretation of mark-ups is more meaningful when the group of firms lumped together is more homogenous in terms of business activities compared with highly aggregated sectors such as, for instance, business services or utilities. It should be noted, though, that even at the most detailed level of disaggregation, firms can produce very different services that do not compete in the same market. Going further, Nishimura *et al.* (1999) show that the uniformity of mark-ups (and of the effect of fixed costs) within an industry can be rejected, implying a limited meaning of industry-specific mark-ups. Given the limited length of time series in the *Amadeus Database*, estimating firm-specific mark-ups is not possible. Hence, the intermediate solution of high disaggregation of sectors is chosen, where the term "sector" refers to a more homogenous group of firms *vis-à-vis* analyses using industry-level data.

At the same time, there are also drawbacks to using firm-level data, in particular related to the representativeness of the dataset. As discussed more in detail below, the extent to which large firms are overrepresented and small ones underrepresented in the *Amadeus Database*, the major source of data for the analyses, differs by country, which calls for caution in cross-country comparisons. In addition, the methodology applied here implies that mark-ups of individual firms are unweighted, *i.e.* pricing policies of a small firm are given as much weight as those of a large firm. This creates an upward bias in estimates where small firms charge higher mark-ups (due, for instance, to product differentiation) and a downward bias where larger firms have larger pricing power. Given, however, the underrepresentation of small firms in the *Amadeus Database* (discussed below), this source of bias may not be important. Also, due to constraints in the data drawn from the *Amadeus Database*, mark-ups can be estimated only for countries and sectors where there are a sufficient number of firms and the limited number of years does not allow for estimating mark-ups for individual firms.

1.1. How are the estimates obtained?

Developments in the theoretical and empirical literature over the past decades suggest a departure from the standard assumptions of the neoclassical production theory in terms of perfect competition and constant returns to scale. This departure allows for the assumption of monopolistic firms charging mark-ups over marginal costs and opens up new avenues for the estimation of such mark-ups. Here the Roeger (1995) method is applied, which has been widely used, owing to its simplicity.

Roeger (1995) explains the difference between the primal and the dual Solow residuals as a result of imperfect competition, and his method has the beauty of simplicity relative to the method pioneered by Hall (1988), overcoming the need to use variables in volumes and to apply an instrumental variables technique. Roeger (1995) exploits the cancelling out of the unobservable productivity term (present in both residuals) when subtracting the two Solow residuals from each other. This way, the price-cost margins can be estimated consistently by standard econometric techniques. The results obtained this way are mark-ups over average cost and not marginal cost.

The production technology is assumed to be defined by the neoclassical production function:

$$Y = AF(N,M,K) \tag{1}$$

where Y is output and A is multifactor productivity growth. There are three inputs: N is labour, M is intermediate inputs, K is capital, and $F(.)$ is a homogenous function of degree λ (the degree of returns to scale). The production function is equivalent to a Cobb-Douglas one in the case of constant returns to scale. The firm and year subscripts are subsumed for the sake of simplicity. The inclusion of intermediate inputs allows defining the mark-up ratios using gross output, and hence overcoming the upward bias that would result if value added were used instead (Norrbin, 1993, and Basu, 1995). After log-differentiation[6] and re-arranging:

$$SR_{primal} = y - \alpha_N n - \alpha_M m - \alpha_K k = (1 - B)a - B(y - k) \tag{2}$$

where SR_{primal} is the primal Solow residual (the lower case indicates log-differentiation), α_i is the revenue share of factor i and B is the Lerner index, which is closely related to the mark-up μ:

$$B = 1 - \frac{1}{\mu} \tag{3}$$

where μ is defined as price over marginal cost.

The dual, or priced-based Solow residual is derived by using the cost-function associated with the production function in equation (1):

$$SR_{dual} = \alpha_N w + \alpha_M p_m + \alpha_K r - p = (1 - B)a - B(p - r) \tag{4}$$

where w is the growth rate of wages, p_m of material prices, r of the rental price of capital and p of output. By subtracting (4) from (2) and adding an error term, B can be estimated as Roeger (1995) showed. As the unobservable productivity term, a cancels out with this subtraction, this equation is relatively easy to estimate. The estimation of equation (2), in contrast, would result in bias and inconsistency of the mark-up estimates as the input variables are correlated with the productivity shocks.

After differentiation and under the assumption of constant returns to scale ($\lambda = 1$), the equation to estimate (after adding an error term) is obtained:

$$(p + y) - \alpha_N (w + n) - \alpha_M (p_m + m) - (1 - \alpha_N - \alpha_M)(r + k) = B[(p + y) - (k + r)] \tag{5}$$

where the first term in the left hand side is nominal output, the second is wage cost multiplied by the estimated coefficient on labour α_N from the production function, the third is material costs multiplied by the estimated coefficient on material inputs α_M and the fourth is the rental price of capital multiplied by the estimated coefficient on capital $(1 - \alpha_N - \alpha_M)$, all in differences. The totality of the left hand side is the Solow residual with variables measured in nominal terms. In the right-hand side, B is the Lerner index [(Price – Average Cost)/Price] to estimate, which can be used to compute the mark-ups according to equation (3).

The equation to estimate can also be written as:

$$\Delta z = B\Delta x + \varepsilon \tag{6}$$

where

$$\Delta z = (p + y) - \alpha_N (w + n) - \alpha_M (p_m + m) - (1 - \alpha_N - \alpha_M)(r + k) \tag{7}$$

$$\Delta x = (p + y) - (k + r) \tag{8}$$

and ε is the error term.

Oliveira Martins *et al.* (1996) show that the equation to estimate the mark-up can also be derived from the direct definition of the mark-up over average cost:

$$\frac{P}{AC} = \frac{P * Y}{(W * N + M * P_M + R * K)} = \frac{\mu}{\lambda} \tag{9}$$

where *AC* is average cost and *P, W, P_M* and *R* are the prices of output, labour, intermediate inputs and capital, respectively; whereas λ is an index of returns to scale (*i.e.* average costs over marginal costs) and μ is the mark-up.

By differentiating, dividing by *P*Y* and rearranging:

$$\Delta z = [\lambda(B - 1) + 1]\Delta x + \varepsilon \tag{10}$$

where Δz and Δx are defined as earlier. Oliveira Martins *et al*. (1996) demonstrate that Roeger's equation provides an unbiased estimate of the Lerner index *B* only in the case of constant returns to scale ($\lambda = 1$). Indeed, in the presence of increasing returns to scale, the mark-up estimation would be downward biased (marginal cost < average cost) and the reverse holds in case of decreasing returns to scale (marginal cost > average cost).

Following Dobrinsky *et al.* (2004), to estimate the mark-ups under non-constant returns to scale, the returns to scale index, λ, was estimated from the production function, and the new mark-up computed from the Lerner index obtained in the case of constant returns to scale is:

$$B' = 1 - \frac{\lambda}{\mu} \tag{11}$$

1.2. Data

Most of the data are obtained from a subset of the *Amadeus Database* comprising nearly 1.5 million European companies.[7] The subset was obtained by including any company that meets one of the following criteria, depending on the reporting country:

- France, Germany, Italy and the United Kingdom:
  - ❖ operating revenue equal to at least EUR 1.5 million;
  - ❖ total assets equal to at least EUR 3 million; or
  - ❖ the number of employees equals at least 20.
- Austria, Belgium, Czech Republic, Denmark, Finland, Greece, Hungary, Iceland, Ireland, Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden and Switzerland:
  - ❖ operating revenue equal to at least EUR 1 million;
  - ❖ total assets equal to at least EUR 2 million; or
  - ❖ the number of employees equals at least 20.

This way, the sample selection is biased toward large firms, which is a major caveat of using Amadeus. Moreover, both the coverage and the extent to which different firm sizes are represented in the database differ by country. Large firms are overrepresented in Amadeus in general, but the extent of overrepresentation appears to be particularly large in Central European countries. This, coupled with low coverage in these countries, calls for caution in interpreting the results obtained for these countries. Furthermore, the exclusion of micro-firms implies very different selection bias in, for instance, Italy, where they produced nearly one-third of value added and employed 47% of the workforce in 2006, and France, where they produced 21% of the value added and employed less than a quarter of the workforce in the same year (Eurostat). The sample selection bias is further aggravated by the fact that firms with larger capital stocks can overcome greater negative productivity shocks that imparts a downward bias on the capital coefficient (Van Biesebroeck, 2007).

The dataset contains firms' balance sheets and profit and loss accounts and information on stocks, shareholders, subsidiaries and activities. Company-specific nominal data needed for the estimation of the production function and the mark-ups are directly obtained from the *Amadeus Database*. For the output variable, operating revenue or sales is used, as value added can be interpreted as an output measure only under perfect competition (Basu and Fernald, 1997). Moreover, defining the mark-up over value added can introduce an upward bias in estimation (Norrbin, 1993). For labour, the number of employees is used and for capital, fixed assets. For material – in most countries – the variable called "material costs" is used, but for Denmark, Greece, Iceland, Ireland, the Netherlands and the United Kingdom, cost of goods sold is used. For wages, there is a straightforward variable, except in the case of Greece, where due to the lack of the wage expenditure variable (or company-specific information on the wage rate), mark-ups were estimated using the industry-specific wage expenditure from the *OECD STAN Database*.

The rental price of capital is calculated from the following equation:

$$R = ((i - \pi_e) + \delta)pk \tag{12}$$

where i is the long-term interest rate, π_e is expected inflation, ε is the depreciation ratio and pk is the fixed-asset investment deflator. For the calculation of the rental price of capital, the yield on benchmark government ten-year bonds (or similar maturity) from the *OECD Economic Outlook Database* is used;[8] expected inflation is proxied by the Hodrick-Prescott-filtered GDP deflator, which is also extracted from the *OECD Economic Outlook Database*. The depreciation ratio is company-specific and is calculated from the depreciation costs available in the *Amadeus Database*. It should be noted, however, that these depreciation costs are an accounting definition rather than an economic one and are affected by country-specific rules such as fiscal incentives in the form of accelerated depreciation. An alternative could have been to use a uniform rate for depreciation such as 8% or 4%, as in the literature. Such imposed rates, however, would have been arbitrary, and without *a priori* information about cross-sector variation, only a uniform rate would have been feasible. For the fixed-asset investment deflator, sector-specific deflators are used, with the exception of Greece, Iceland, Poland, Portugal, Sweden, Switzerland and the United Kingdom, where, in the absence of such data, the economy-wide deflator for business investment from the *OECD Economic Outlook Database* is applied.

The *Amadeus Database* classifies firms into 4-digit and 2-digit NACE categories. Due to the limited number of companies in several countries at the 4-digit level, the industries were reclassified into a mix of 2- and 4-digit NACE categories, avoiding overlap. A particular feature of this work is the disaggregation of the business service category into its sub-components. Indeed, while computer and related activities, research and development, legal, accounting, advertising, engineering and architecture services present certain common features (they are small in size and knowledge- and reputation-based activities), they cannot be treated as a homogenous group given that the degree of market segmentation for these services and their interface with technology, *inter alia*, differ largely. It should be noted that the sectors can never be sufficiently disaggregated to define a genuinely homogenous group of firms, as even at the most disaggregated sectoral level firms may compete in different markets. Moreover, the well-known diversity among firms in terms of scale, production technology and profitability tends to imply that estimation of mark-ups should be done at the firm level, allowing firm-specific market and technological conditions. Given data constraints, however, mark-ups were estimated for 28 service sectors, including electricity, gas, steam and hot water supply, collection, purification and distribution of water, construction, car sale and gasoline retail,

wholesale trade, retail trade, hotels and restaurants, land transport, water transport, air transport, other transport activities, post, telecommunications, financial intermediation,[9] activities related to financial intermediation, real estate, renting of machinery and equipment, computer and related activities, research and development, legal services, accounting services, advertising services, engineering and architecture services, education and other community, social and personal services. It should be noted that in the *Amadeus Database* the sector classification of firms depends on their primary activity, therefore with multi-activity firms, in an extreme case, the main activity may not even engage half of their production capacity. This could bias mark-up estimates obtained at the sectoral level, no matter how disaggregated the sectoral level is.

Given the coverage of the *Amadeus Database* with 20 countries[10] and the selection of 28 service sectors, ideally there should be 560 mark-up estimates. In reality, however, given the limited number of observations for some countries and several sectors, the number of estimated mark-ups is substantially lower.

1.3. Choices of estimation and specification techniques

Mark-ups are estimated using two alternative techniques that differ at the first step of estimating the production function; factor shares were determined by: *i)* using an ordinary least squares (OLS) method with fixed effects; or *ii)* computing the shares. The OLS fixed-effects method assumes that productivity that influences firms' choice is a time-invariant firm-specific attribute and corrects for it by including firm fixed effects.[11] The second method relies on computation of the revenue shares of factor inputs instead of econometric estimation as in Görg and Warzynski (2003). The OLS fixed effects method can produce country and sector estimates, while computed factor shares are obtained at the firm level. The application of the two methods allows for the exploitation of the richness of information related to heterogeneity at the country, sector and firm level (and across time). It should be noted, however, that neither of the methods is without caveats. As shown in Annex A1 and elaborated in Basanetti *et al.* (2008), input elasticities are equal to factor shares only in the case of perfect competition; hence the estimated elasticity has an upward bias for labour and material coefficients (given that the elasticity equals mark-up times factor shares, and that under imperfect competition the mark-up is expected to be larger than one), and in the case of constant returns to scale, a downward bias for the coefficient on capital. At the same time, the computed factor shares assume no measurement error in production inputs, an unlikely event in the case of micro-data.

The second step, which is the estimation of the Lerner indices, is identical in the two cases. The Lerner indices were estimated by OLS with and without fixed effects, year dummies and time trend. They were jointly estimated for all countries and all sectors in the sample. The rational for the joint estimation is that the pricing behaviour of firms may be influenced by that of firms in other countries or industries, even though services are much less traded than goods. The mark-ups were then retrieved from equation (3), and the corresponding standard errors were computed by the delta method as in Görg and Warzynski (2003). Both estimation methods were applied for two specifications: *i)* assuming constant returns to scale (to obtain the Lerner index, *B*); and *ii)* relaxing the constraint of constant returns to scale (to test for the validity of the assumption of constant returns to scale). The validity of the assumption of constant returns was checked by econometric tests, and where constant returns were rejected, this constraint was relaxed and the return to scale index was introduced to correct for the estimation bias.

1.3.1. From the assumption of common input coefficients to sector- and country-specific ones

An easy way to estimate the mark-ups (Tables 1-21) would be to assume that the production functions are identical across countries and industries. A simple F-test, however, shows that even for the 20 European countries covered by the database we cannot assume that firms in the same sector behave the same way across countries (Table 22). By the same token, firms in the same countries but in different sectors exhibit different characteristics (Table 23). Therefore, country- and industry-specific input coefficients need to be estimated. To account for interaction between industries and countries, data for different sectors and countries are pooled in a single dataset and the input coefficients are estimated simultaneously for all industries and all countries. The estimated coefficients are then used as inputs for the second step where mark-ups are derived. The second approach, where the factor shares are computed and not estimated, implies firm-specific shares, *i.e.* the input coefficients are computed at the firm level.

1.3.2. Relaxing the assumption of constant returns to scale

Constant returns to scale may not hold for all industries; hence its validity needs to be tested. The hypothesis of constant returns to scale was rejected for several groups (Tables 24-25); therefore the mark-ups were re-estimated under the relaxation of the assumption of constant returns as in Dobrinsky *et al.* (2004). More specifically, the returns to scale index was first derived as a function of the estimated input coefficients; then the mark-up estimates obtained from equation (6) were adjusted according to equation (11). The standard errors for the mark-ups under non-constant returns to scale were obtained using the delta method.

Equation (7) implies that all firms in the same NACE 2- and 4-digit industries in a given country have the same returns to scale index, and hence the same production technologies. This would be quite a plausible assumption under perfect markets where all firms have the same production efficiency, as less efficient firms are driven out of the market by competition. In imperfect markets, however, production technologies may differ and hence there may be varying returns to scale indices across firms in the same industry. As the magnitude of the returns to scale index is an empirical issue, and the empirical literature suggests that firms of similar sizes may have similar magnitudes of the index (Dobrinsky *et al.*, 2004), the inclusion of only medium and large firms in the sample may justify this assumption.

To summarise the estimation method: first, the neoclassical production function with three inputs was estimated, and factor shares were derived from the elasticities of the respective inputs and calculated as in Görg and Warzynski (2003). It should be noted that neither way of retrieving factor shares is ideal, as input elasticities are not identical to factor shares in the case of imperfect competition and the calculation of factor shares assumes the lack of measurement error in inputs, which is not likely in the case of firm-level data. Using these factor shares, the calculated rental price of capital and nominal values of variables from the *Amadeus Database*, the Lerner indices are estimated applying four specifications (OLS with year dummies and with and without fixed effects, and for the computed factor shares, year dummies and trends). The mark-ups can directly be computed from the obtained mark-ups and the corresponding standard errors by applying the delta method. In the last step, it is verified whether the production function exhibits constant returns to scale (both for the estimated and the computed coefficients) and if not,

the mark-ups are adjusted as suggested by Dobrinsky *et al.* (2004) and the corresponding standard errors are computed by the delta method. The mark-ups are obtained by country and by industry, which is made necessary by the rejection of the hypothesis that input coefficients are common across countries or industries.

1.4. How large are the estimates and how do they compare across countries and sectors?

There are no priors as to the magnitude of mark-ups except that they are expected to be larger than one. This is due to the fact that the demand curve faced by a monopolist is downward sloping and the elasticity of demand for a downward-sloping demand curve is negative. The mark-up and the elasticity of demand · are related the following way:

$$\mu = \frac{1}{1+\frac{1}{\eta}} \tag{13}$$

Mark-ups are expected to be higher in service than in manufacturing industries not only because service industries are subject to more product and labour market regulations, but also because international exposure is limited for most services. There are only a few services that are considered as widely traded; these include transport, finance, computer and information technology, communications and construction, and some, such as legal services, are traded only to a very limited extent.

The estimated mark-ups confirm large heterogeneity across sectors and countries. This is not surprising, given that sector-specific characteristics affect the mark-ups companies can charge over average costs, and that the forces driving competition – and hence reducing mark-ups – vary across sectors and countries. Notwithstanding this heterogeneity in the estimated mark-ups, some general trends can be identified. It should be noted that any cross-sectoral comparison should be done with care, as mark-ups may be subject to sector-specific measurement errors or other sector specificities (such as varying risk *premia* included in the cost of capital), which are partly accounted for in the fixed-effect specification. With this caveat in mind, the highest mark-ups in general are observed in real estate and renting, which are characterised by a high level of asymmetric information between suppliers and customers giving rise to pricing powers by suppliers. Indeed, owing to the high degree of information asymmetry, the price of a service does not infer the quality of the service, and consumers need more information to make a decision. In this case, regulation may reduce the information asymmetry and the consequent transaction costs and enhance transactions (Molnar *et al.*, 2008). In addition to such economic reasons, there is a possibility of upward bias induced by measurement errors of capital (as pointed out in Christopoulou and Vermeulen, 2008), which, given higher capital intensity of these sectors, may be higher.[12]

Mark-ups are also high in professional services, where human capital is a major input, reputation is a key asset and most products are customer-specific, and hence markets are segmented. Some of these services, such as legal services, are less tradable than other professional services, implying even higher mark-ups. Network industries, in general, exhibit higher mark-ups than inherently competitive non-network services owing to the large sunk and fixed costs these industries have to assume. Networks can also deliver valuable network externalities. Such features of network industries may inhibit the development of competitive markets. Among network services, mark-ups in telecommunications are relatively lower, probably implying higher competitive pressures in telecommunications markets and

increasingly demanding customers with respect to service quality and prices. Mark-ups are low in highly traded services such as construction or computer services, as well as in transportation and trade-related activities, implying large competitive pressure in these industries.

Among countries in the dataset, the Central European OECD members exhibit the highest mark-ups, alongside Italy, Portugal and Sweden. At the other end of the spectrum, the United Kingdom and some Scandinavian countries seem to have the lowest mark-ups. The large continental countries of France, Germany and Spain are in-between these two groups.

The following sector-specific discussion of some of the findings will give some insights into the differences in mark-ups across sectors and countries. Estimates obtained by both methods (*i.e.* with input coefficients estimated by fixed-effect OLS and computed input shares) are presented to show the robustness of results. The relative size of the estimates differs somewhat, with the computed method having an upward bias more often than the other way around. The upward bias may be related to the higher degree to which firm heterogeneity is captured in the computed method and which may raise measurement problems. The ranking of countries and sectors is broadly consistent across methodologies.

1.4.1. Mark-ups are high in professional services

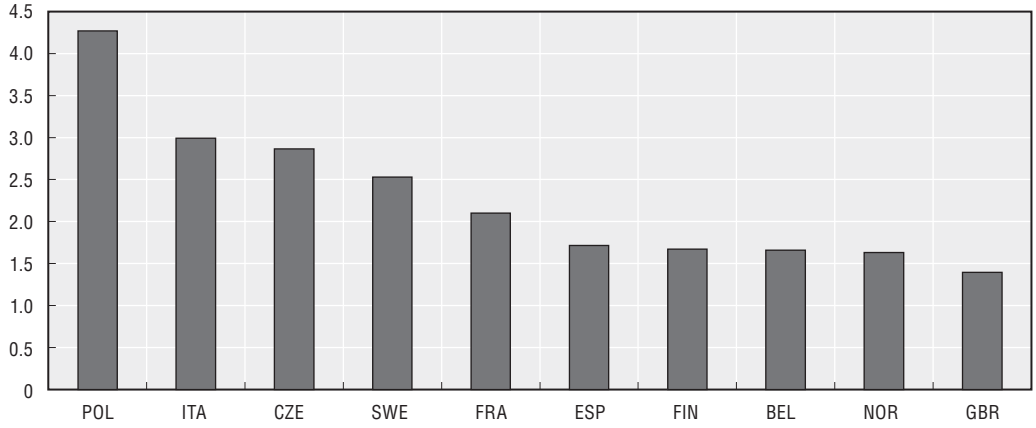
In general, mark-ups are high in professional service sectors in most countries. Not surprisingly, given the prevalence of customer-specific products, markets are highly segmented. In segmented markets, suppliers have a certain degree of monopoly due to switching costs that are manifest in discretionary price settings. In architectural and engineering services, Finland, Greece, Norway, Spain and the United Kingdom appear to have relatively high competitive pressure and therefore low mark-ups (Figure 1). Most other countries have high mark-ups in this sub-sector, *e.g.* Italy, Poland, Sweden and the Czech Republic.

In accounting, there are fewer countries where data availability allowed for the estimation of mark-ups (given the small number of large and the large number of small players in this market, and also the limited sample of medium- to large-size firms). In countries for which mark-ups were estimated, they are generally high, with the exception of Finland, France, Greece, Iceland, Norway and Poland. The high mark-ups in accounting could be explained by the relatively low tradability of accounting services. Owing to local qualification and licensing requirements and the differences in accounting standards across countries, very often the large international accounting firms formed partnerships with local firms to overcome the effects of such national regulations (WTO, 1998a).

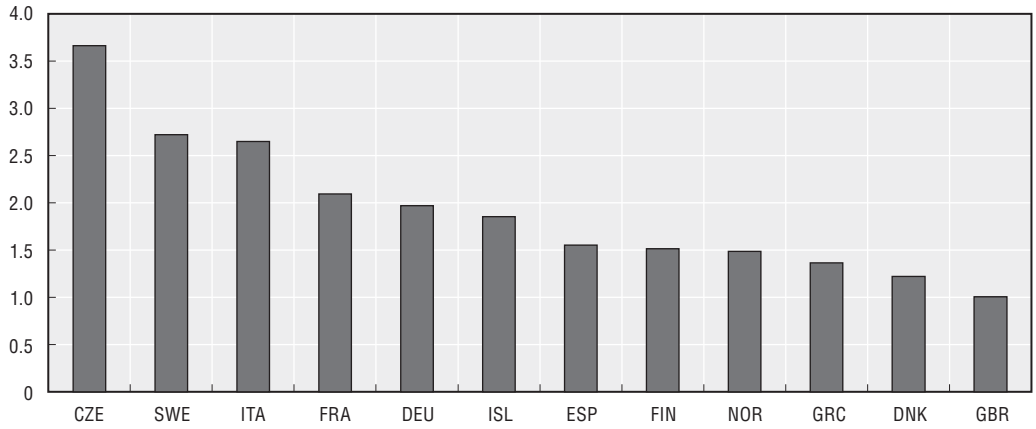
Given the small size of legal services firms, in general, and the exclusion of such firms from the sample, the mark-ups in this sector could be estimated only for a handful of countries. Finland and Greece again appear to charge smaller mark-ups over average costs, while in most other countries for which it could be estimated, the mark-ups are relatively high, *e.g.* in Italy, Norway, Poland and Sweden. Individual professionals that provide legal services tend to specialise in different fields of domestic law, resulting in market segmentation and reduced international exposure, largely owing to qualification requirements and the local nature of domestic law (WTO, 1998b). Recently, the number of lawyers practising in foreign jurisdictions has increased, as corporate clients extend their ties overseas. Anglo-Saxon countries have a comparative advantage in supplying these

Figure 1. **Mark-ups in architecture and engineering services are high**

Panel A. Mark-ups in the architecture and engineering services sector obtained by estimating input coefficients



Panel B. Mark-ups in the architecture and engineering services sector obtained by computing input coefficients



Note: The two series of mark-ups were obtained using two different estimation methods; therefore their absolute magnitudes are not comparable.

Source: Authors' estimation.

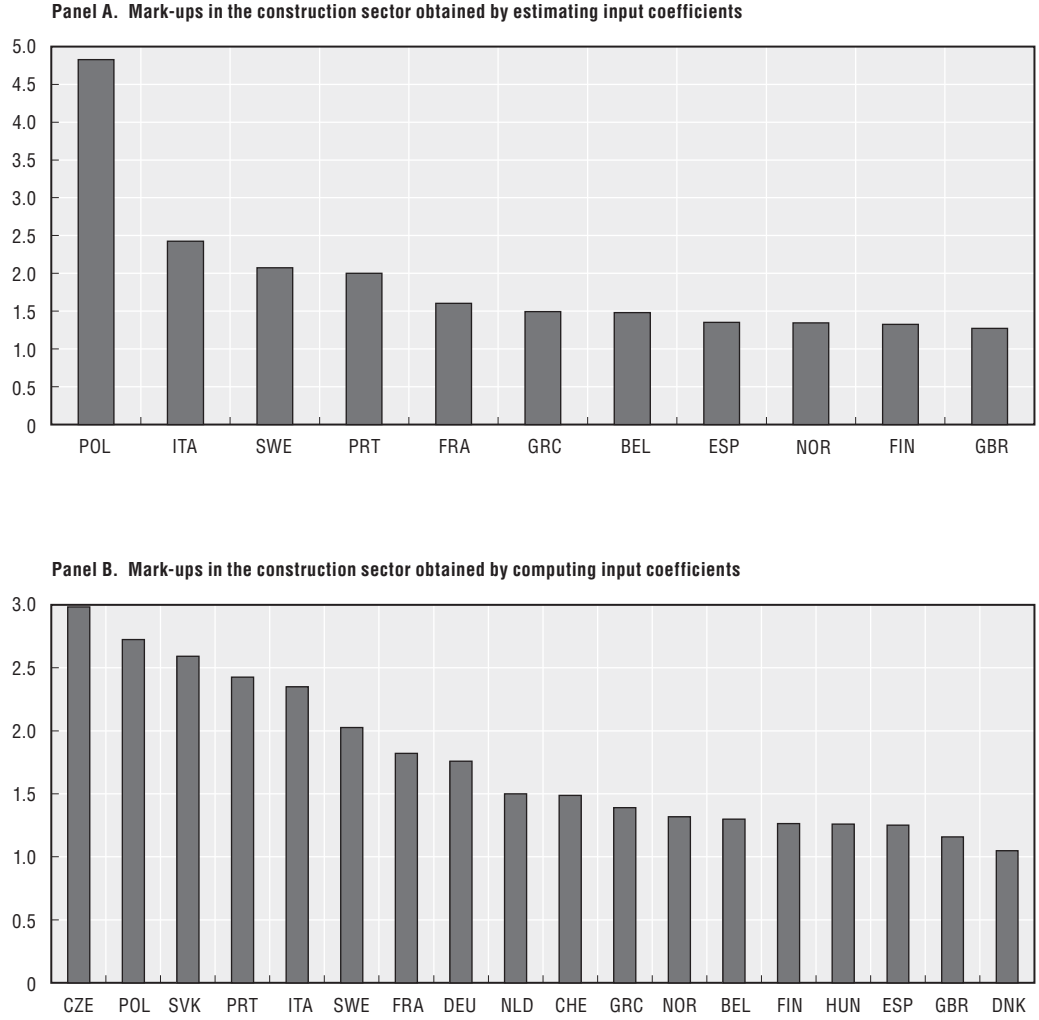
services, as they mainly rely on large and medium-sized law firms rather than on individual professionals, and given that the US-UK law plays a major role in international transactions (Hook, 2007, and WTO, 1998b). As such firms focus on commercial disputes, they do not, in general, compete with local lawyers.

Professional services are inherently competitive, and the exceptionally high mark-ups in this sector may indicate inadequate competitive pressure. Unnecessary regulation and the lack of recognition of qualifications may give a particular boost to firms' pricing power in this sector.

1.4.2. Mark-ups in the construction sector are relatively low in general, with elevated levels in some countries

Generally, the construction sector appears to exhibit relatively low mark-ups (Figure 2), at least in comparison with some other service industries. This finding is not surprising, given that construction services are highly traded and are to some extent standardised. This

Figure 2. **Mark-ups in the construction sector are relatively low**



Note: The two series of mark-ups were obtained using two different estimation methods; therefore their absolute magnitudes are not comparable.

Source: Authors' estimation.

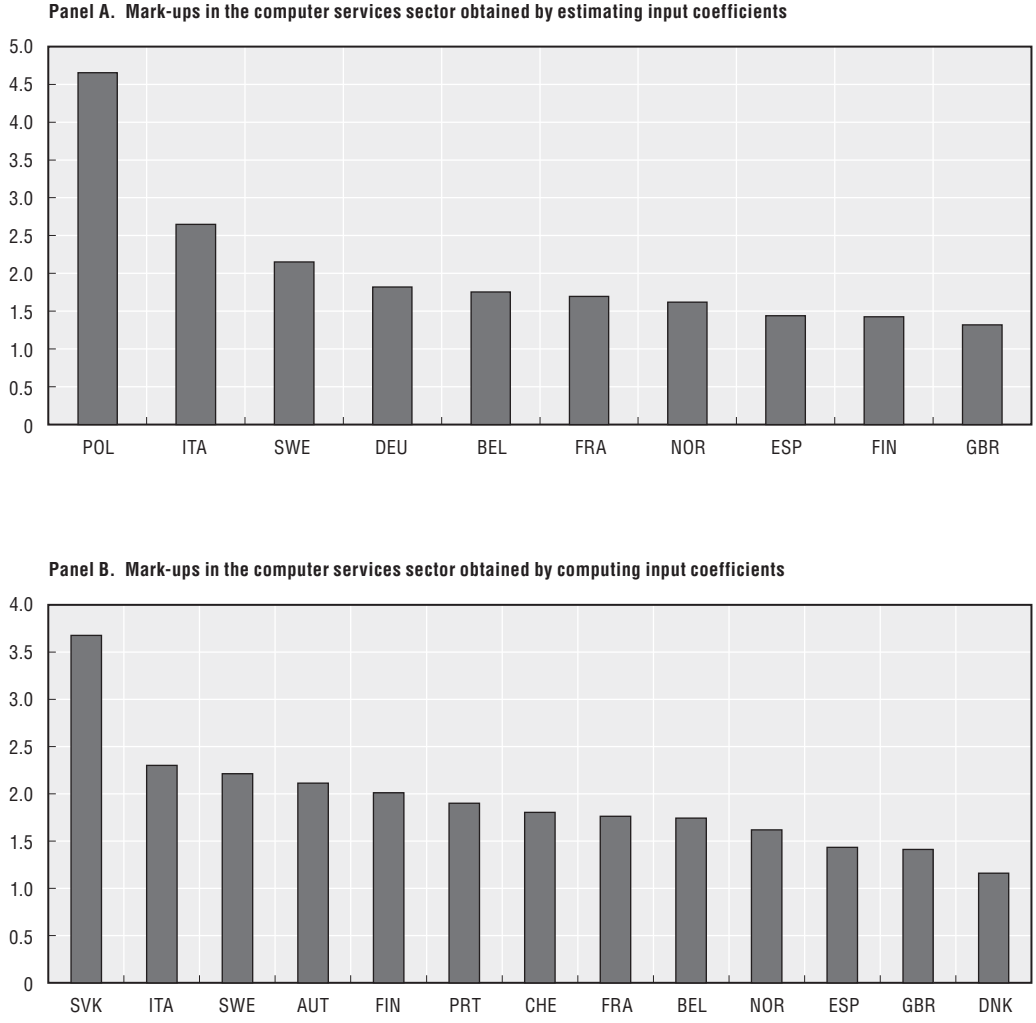
wedge is very small in Denmark, relatively small in the United Kingdom, Spain, Hungary, Finland, Belgium, Norway and Greece, but relatively high for other Central European countries, Sweden, Portugal and Italy. Given the large number of players in the sector in most countries, mark-ups in construction were obtained using the fixed-effect method for the estimation of the input coefficients for as many as 15 countries. With the computed input coefficients, the number of estimates is even larger (18), though this method tends to overestimate mark-ups. The sector exhibits non-constant returns to scale in all countries in the sample.

1.4.3. Competitive pressure in computer services implies small mark-ups in most countries

In contrast to other business services, the computer services market is unregulated in the countries in the sample and computer services are generally tradable and can easily relocate abroad (Kox, 2002). Moreover, the importance of customised software has declined

following the diffusion of microcomputers and software packages. As expected under such circumstances, the analysis points to relatively low mark-ups in most countries (Figure 3). Exceptions are the Central European countries and, to a lesser extent, Italy, Sweden and Austria. Most computer services sectors are characterised by non-constant returns to scale except in Finland, where the constant returns to scale hypothesis was not rejected.

Figure 3. **Mark-ups in computer services are relatively low in most countries**



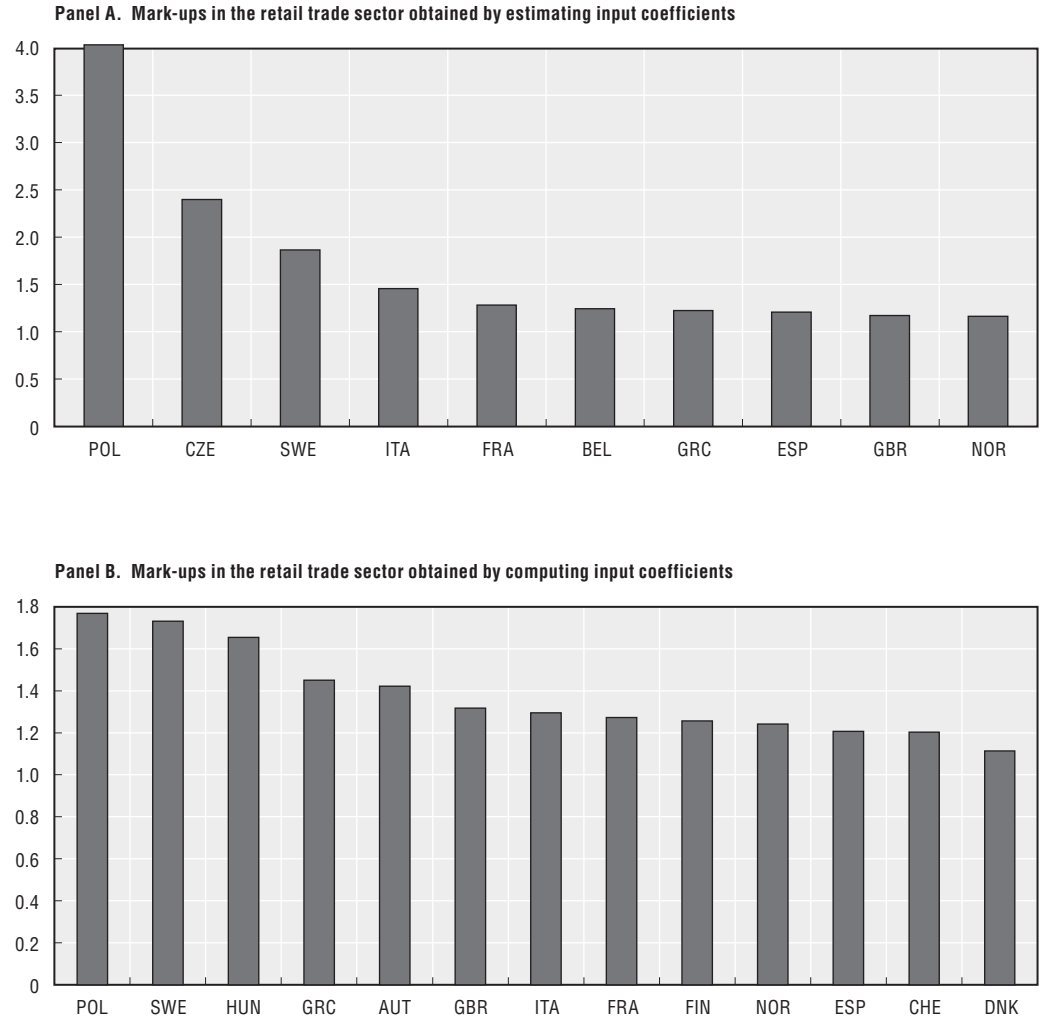
Note: The two series of mark-ups were obtained using two different estimation methods; therefore their absolute magnitudes are not comparable.

Source: Authors' estimation.

1.4.4. Low mark-ups in the retail trade sector suggest strong competition

The retail trade sector appears to be among the most competitive service sectors as the low level of the estimated mark-up ratios suggests (Figure 4). Very often the competitive pressures stem from foreign affiliates and a large number of players in the market. Notwithstanding the large number of players, the retail market is becoming increasingly concentrated, with retail chains selling homogenous products and competing on prices (oligopoly à la Bertrand) (WTO, 1998c). The ordering of countries according to the mark-up

Figure 4. **Mark-ups in retail trade are low**



Note: The two series of mark-ups were obtained using two different estimation methods; therefore their absolute magnitudes are not comparable.

Source: Authors' estimation.

ratios in the retail sector follows a similar pattern to that in other sectors, with Central European countries and Sweden at one end of the spectrum and the other Scandinavian countries at the other end.

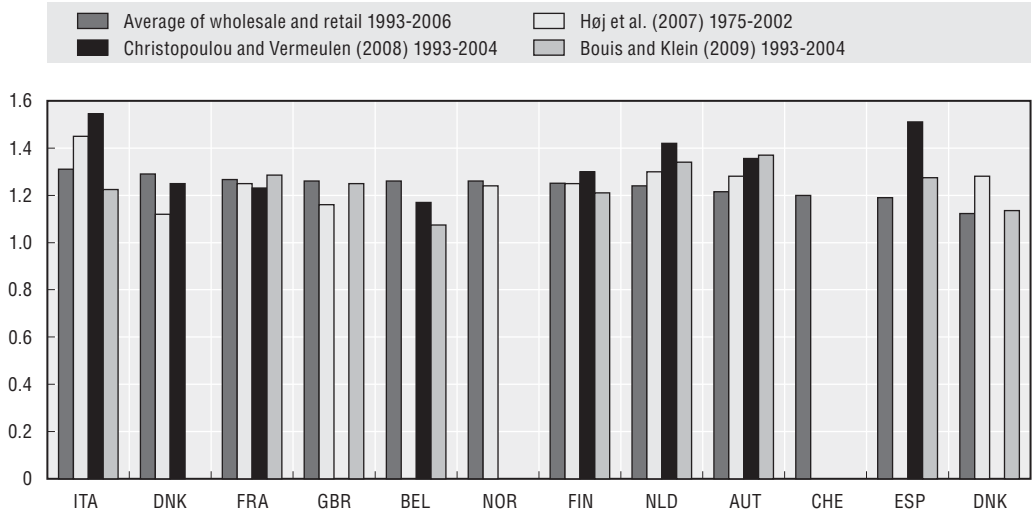
1.4.5. *Comparing the newly obtained mark-ups with other estimates*

Comparability of the newly obtained mark-ups with previous estimates is limited, but the relative magnitudes of mark-ups across countries are similar in some countries and sectors and different in others. Oliveira Martins *et al.* (1996) provided the first comprehensive mark-ups for OECD countries, though their estimation of mark-ups was limited to manufacturing industries and to using sectoral data. As noted above, Høj *et al.* (2007) extended the coverage to include up to six services industries (depending on the country) and estimated the mark-ups for 19 countries over the 1975-2002 period. Christopoulou and Vermeulen (2008) and Bouis and Klein (2009) provide further estimates at the industry level for 9 and 11 countries, respectively.

In trade (wholesale and retail), where owing to the large number of observations mark-ups were estimated for a number of countries, the new estimates are comparable with the ones obtained in Høj *et al.* (2007), Christopoulou and Vermeulen (2008) and Bouis and Klein (2009) (Figure 5).

Figure 5. **Newly estimated mark-ups for retail and wholesale trade are comparable with other estimates**

The average of the new mark-ups in the wholesale and retail sector and earlier estimates in the wholesale and retail trade



Source: Authors' estimation, Høj *et al.* (2007), Christopoulou and Vermeulen (2008) and Bouis and Klein (2009).

In other sectors, however, the difference in estimated mark-ups seems larger across studies. Furthermore, there is a variation in terms of differences in mark-ups across countries. In the case of Belgium, for instance, there is a 0.8 and 0.83 correlation between the present estimates and those by Christopoulou and Vermeulen (2008) and Bouis and Klein (2009), respectively, but the correlation coefficient is smaller for other countries. These findings may imply that any potential bias may be related to both industry- and country-specific effects. Indeed, as pointed out earlier, the sample selection bias has both a country and an industry dimension. Not only is the data coverage biased toward large firms, but the coverage of the database and the extents of this bias are different across countries. Moreover, the overrepresentation of large firms in the *Amadeus Database* implies varying coverage across industries, as average firm size is very much industry-specific. The estimated mark-ups tend to be bigger in countries where the extent of overrepresentation of large firms is larger, such as in Central Europe.

Another source of bias is measurement errors, which may be related to the measurement of inputs, in particular capital and the cost of capital. The measurement of capital can be problematic for firm-level analyses and, as pointed out by Christopoulou and Vermeulen (2008), measurement errors always lead to an upward bias. Some measurement errors can also be related to the calculation of the rental price of capital, in particular when, for instance, instead of using government bond rates, long-term lending rates are applied, which tend to be higher (this is the case for the Czech Republic and Poland, both among countries with the highest estimated mark-ups). A further source of bias is related to the way the factor shares are obtained, which also tends to bias the obtained estimates upward. Finally, the adjustment for

non-constant returns to scale introduces an upward bias as well, as in most cases the production functions exhibit decreasing returns to scale. This bias tends to be particularly large in Central Europe and Italy in many cases and also for other countries in particular industries.

2. What have we learned and what else could be done?

Mark-ups provide a comparative perspective on competitive pressures in markets in different countries and industries. It is empirically shown that mark-ups are statistically different across countries and service industries. In general, the estimated mark-ups were high for industries where a high degree of information asymmetry prevails and products are customer specific, such as real estate, renting and utilities and professional services, while mark-ups tended to be substantially lower for traded services and industries that produce more standardised products, such as construction, computer services, retail and wholesale trade and catering. Most service industries exhibit non-constant returns to scale; hence the relaxation of the constant returns to scale assumption was necessary.

There is also wide variation across countries in terms of the size of the estimated mark-ups. Competitive pressure according to these mark-ups should be significant in the United Kingdom and most Scandinavian countries, and relatively low in Central European countries, Sweden and Italy. Spain, Germany and France are in between these two groups. The study highlighted some sources of potential bias related to sample selection, measurement error and production technology (returns to scale).

To allow for comparison across a larger number of OECD countries, the analyses could be extended to non-European members using the *Orbis Database*. The methodology applied could be further refined, for example, by using the Levinsohn-Petrin method to obtain the input coefficients of the production function. Some of the measurement errors could also be reduced. In addition, in future analyses, competitive pressures stemming from regulation could be separated from pressures stemming from other sources using the newly estimated mark-ups.

Table 1. **Estimated mark-ups for services industries in Austria, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.										
4100	Collection, purification, etc.										
4500	Construction										
5000	Sale, maintenance, etc.										
5100	Wholesale trade, etc.						1.01***	0.13	1.01***	0.14	0
5200	Retail trade						1.42***	0.05	1.42***	0.05	0
5500	Hotels and restaurants						1.91***	0.11	1.9***	0.11	0
6000	Land transport						1.82***	0.07	1.81***	0.07	0
6100	Water transport						1.76***	0.00	1.67***	0.00	0
6200	Air transport						3.69***	0.13	3.7***	0.20	0
6300	Supporting, etc.						2.9***	0.07	2.87***	0.08	0
6410	Post and courier activ.										
6420	Telecommunications										
6500	Financial intermediation										
6700	Activ. auxiliary to fin. int.						1.45***	0.06	1.48***	0.08	0
7000	Real estate										
7100	Renting						2.29***	0.00	2.27***	0.00	0
7200	Computer activities						2.11***	0.10	2.11***	0.10	0
7300	Research and development						1.77***	0.04	1.83***	0.01	0
7400	Other business activ.										
7411	Legal activ.										
7412	Accounting, etc.										
7413	Market research, etc.										
7414	Bus. and man. consultancy activ.										
7415	Man. activ. of holding companies										
7420	Architectural, etc.										
8000	Education										
7599	Other										

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 2. **Estimated mark-ups for services industries in Belgium, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.	0.89***	0.13	0.93***	0.12	1					
4100	Collection, purification, etc.						2.6***	0.18	2.58***	0.17	0
4500	Construction	1.48***	0.04	1.48***	0.03	0	1.3***	0.02	1.3***	0.02	0
5000	Sale, maintenance, etc.					0					
5100	Wholesale trade, etc.	1.34***	0.01	1.34***	0.01	0	1.26***	0.01	1.27***	0.01	0
5200	Retail trade	1.24***	0.03	1.23***	0.03	0					
5500	Hotels and restaurants	1.37***	0.05	1.37***	0.05	1	2.63***	0.26	2.63***	0.25	0
6000	Land transport						1.71***	0.06	1.71***	0.06	0
6100	Water transport										
6200	Air transport										
6300	Supporting, etc.	1.62***	0.08	1.6***	0.05	0	1.5***	0.04	1.51***	0.04	0
6410	Post and courier activ.										
6420	Telecommunications										
6500	Financial intermediation	1.89***	0.09	1.87***	0.07	0	1.88***	0.20	1.89***	0.20	0
6700	Activ. auxiliary to fin. int.										
7000	Real estate	2.99***	0.12	2.77***	0.09	0	1.89***	0.13	1.89***	0.13	0
7100	Renting	2.19***	0.13	2.16***	0.14	0	1.55***	0.04	1.55***	0.04	0
7200	Computer activities	1.75***	0.07	1.82***	0.07	0	1.74***	0.06	1.75***	0.06	0
7300	Research and development					1					
7400	Other business activ.	1.69***	0.05	1.67***	0.04	0	1.5***	0.05	1.5***	0.05	0
7411	Legal activ.										
7412	Accounting, etc.						1.75***	0.05	1.74***	0.04	0
7413	Market research, etc.										
7414	Bus. and man. consultancy activ.	1.48***	0.07	1.44***	0.07	0					
7415	Man. activ. of holding companies	2.14***	0.27	2***	0.15	0					
7420	Architectural, etc.	1.66***	0.2	1.63***	0.16	1					
8000	Education						1.5***	0.03	0***	0.03	0
7599	Other	1.87***	0.1	1.85***	0.07	0	1.97***	0.09	1.97***	0.09	0

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 3. **Estimated mark-ups for services industries in the Czech Republic, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.										
4100	Collection, purification, etc.										
4500	Construction	2.29***	0.12	2.2***	0.1	0	2.98***	0.13	2.98***	0.13	0
5000	Sale, maintenance, etc.	3.88***	0.13	3.85***	0.1	0	13.52***	0.23	13.5***	0.23	0
5100	Wholesale trade, etc.	4.12***	0.08	4.06***	0.06	0	19.18***	0.11	19.16***	0.11	0
5200	Retail trade	2.4***	0.09	2.32***	0.05	0	12.35***	0.14	12.34***	0.14	0
5500	Hotels and restaurants										
6000	Land transport						3.23***	0.20	3.22***	0.20	0
6100	Water transport										
6200	Air transport						4.04***	0.00	4.03***	0.00	0
6300	Supporting, etc.	2.7***	0.2	2.81***	0.15	0					
6410	Post and courier activ.										
6420	Telecommunications										
6500	Financial intermediation										
6700	Activ. auxiliary to fin. int.										
7000	Real estate										
7100	Renting										
7200	Computer activities										
7300	Research and development						2.39***	0.11	2.37***	0.10	0
7400	Other business activ.	4.58***	0.75	3.81***	0.31	0					
7411	Legal activ.						–8.78***	0.5	–8.55***	0.45	0
7412	Accounting, etc.										
7413	Market research, etc.										
7414	Bus. and man. consultancy activ.										
7415	Man. activ. of holding companies										
7420	Architectural, etc.	2.87***	0.19	2.92***	0.11	0	3.66***	0.19	3.66***	0.19	0
8000	Education	2.41***	0.1	2.39***	0.06	0					
7599	Other						3.01***	0.13	3***	0.13	0

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 4. **Estimated mark-ups for services industries in Denmark, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.	1.32***	0.07	1.35***	0.07	1	1.16***	0.09	1.16***	0.09	0
4100	Collection, purification, etc.										
4500	Construction						1.05***	0.02	1.05***	0.02	0
5000	Sale, maintenance, etc.						1.09***	0.02	1.09***	0.02	0
5100	Wholesale trade, etc.						1.13***	0.01	1.13***	0.01	0
5200	Retail trade						1.11***	0.01	1.11***	0.01	0
5500	Hotels and restaurants	1.27***	0.05	1.27***	0.05	0	1.23***	0.07	1.23***	0.07	0
6000	Land transport						0.99***	0.01	0.99***	0.01	0
6100	Water transport										
6200	Air transport										
6300	Supporting, etc.	1.26***	0.03	1.29***	0.04	0	1.09***	0.02	1.08***	0.02	0
6410	Post and courier activ.										
6420	Telecommunications						1.47*	0.18	1.47*	0.19	1
6500	Financial intermediation	1.48***	0.08	1.53***	0.1	0	1.42***	0.07	1.42***	0.07	0
6700	Activ. auxiliary to fin. int.	2***	0.76	1.55***	0.35	1					
7000	Real estate										
7100	Renting										
7200	Computer activities						1.16***	0.04	1.16***	0.04	0
7300	Research and development							0.00		0.36	1
7400	Other business activ.						1.09**	0.04	1.09**	0	1
7411	Legal activ.										
7412	Accounting, etc.										
7413	Market research, etc.						1.64*	0.23	1.64*	0.23	1
7414	Bus. and man. consultancy activ.										
7415	Man. activ. of holding companies	1.5***	0.08	1.46***	0.05	0	1.39***	0.11	1.39***	0.11	0
7420	Architectural, etc.						1.22***	0.06	1.22***	0.06	1
8000	Education						1.43***	0.08	1.42***	0.08	0
7599	Other	1.64***	0.06	1.61***	0.05	0	1.21***	0.06	1.21***	0.06	1

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 5. **Estimated mark-ups for services industries in Finland, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.	1.93***	0.07	1.93***	0.07	0					
4100	Collection, purification, etc.										
4500	Construction	1.33***	0.02	1.33***	0.01	0	1.26***	0.02	1.26***	0.02	0
5000	Sale, maintenance, etc.						1.15***	0.01	1.15***	0.01	0
5100	Wholesale trade, etc.	1.32***	0.01	1.32***	0.01	0	1.25***	0.01	1.25***	0.01	0
5200	Retail trade						1.26***	0.02	1.26***	0.02	0
5500	Hotels and restaurants	1.47***	0.03	1.46***	0.03	0	1.66***	0.03	1.66***	0.03	0
6000	Land transport	1.77***	0.02	1.78***	0.03	0	1.39***	0.03	1.39***	0.03	0
6100	Water transport	2.01***	0.17	1.95***	0.11	0					
6200	Air transport										
6300	Supporting, etc.	1.55***	0.06	1.55***	0.04	0					
6410	Post and courier activ.										
6420	Telecommunications										
6500	Financial intermediation	1.68***	0.1	1.66***	0.07	0					
6700	Activ. auxiliary to fin. int.	1.62***	0.26	1.48***	0.19	1					
7000	Real estate	1.79***	0.04	1.77***	0.03	0	1.53***	0.05	1.54***	0.05	0
7100	Renting	1.77***	0.11	1.77***	0.11	0					
7200	Computer activities	1.43***	0.12	1.38***	0.08	1	2.01***	0.16	2.01***	0.16	0
7300	Research and development										
7400	Other business activ.	1.73***	0.04	1.72***	0.03	0	1.49***	0.05	1.49***	0.05	0
7411	Legal activ.	1.98***	0.28	1.97***	0.17	0					
7412	Accounting, etc.	1.69***	0.12	1.66***	0.08	0					
7413	Market research, etc.						1.88***	0.03	1.88***	0.03	0
7414	Bus. and man. consultancy activ.	1.47***	0.07	1.46***	0.06	0					
7415	Man. activ. of holding companies										
7420	Architectural, etc.	1.67***	0.05	1.65***	0.04	0	1.51***	0.04	1.51***	0.04	0
8000	Education	2.57***	0.22	2.59***	0.22	0					
7599	Other	1.83***	0.09	1.81***	0.06	0	1.82***	0.09	1.81***	0.09	0

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 6. **Estimated mark-ups for services industries in France, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.	2.84***	0.16	2.7***	0.12	0					
4100	Collection, purification, etc.	3.14***	0.05	3.17***	0.05						
4500	Construction	1.6***	0.01	1.59***	0	0	1.82***	0	1.82***	0	0
5000	Sale, maintenance, etc.	1.27***	0.01	1.26***	0.01	0					
5100	Wholesale trade, etc.	1.38***	0.01	1.38***	0.01	0	1.26***	0.01	1.26***	0.01	0
5200	Retail trade	1.28***	0.01	1.27***	0.01	0	1.27***	0.01	1.28***	0.01	0
5500	Hotels and restaurants	1.78***	0.04	1.75***	0.03	0	2.12***	0.04	2.13***	0.04	0
6000	Land transport	1.62***	0.01	1.62***	0.01	0	2.07***	0.01	2.08***	0.01	0
6100	Water transport						3.23***	0.09	3.24***	0.09	0
6200	Air transport						3.29***	0.07	3.32***	0.07	0
6300	Supporting, etc.	2.03***	0.04	2.03***	0.04	0	2.76***	0.03	2.77***	0.03	0
6410	Post and courier activ.										
6420	Telecommunications	1.84***	0.2	1.88***	0.16	1	2.54***	0.12	2.55***	0.12	0
6500	Financial intermediation	2.24***	0.25	2.17***	0.19	1					
6700	Activ. auxiliary to fin. int.	1.74***	0.13	1.6***	0.09	1	2.12***	0.12	2.12***	0.12	0
7000	Real estate	2.67***	0.06	2.56***	0.04	0	2.14***	0.05	2.14***	0.05	0
7100	Renting	1.85***	0.12	1.8***	0.07	0	2.4***	0.11	2.39***	0.11	0
7200	Computer activities	1.69***	0.02	1.69***	0.01	0	1.76***	0.02	1.76***	0.02	0
7300	Research and development	2.95***	0.33	2.88***	0.28	0	3.15***	0.28	3.14***	0.28	0
7400	Other business activ.	1.93***	0.03	1.93***	0.02	0	1.79***	0.02	1.79***	0.02	0
7411	Legal activ.										
7412	Accounting, etc.	1.72***	0.03	1.74***	0.02	0	1.66***	0.02	1.67***	0.02	0
7413	Market research, etc.	5.9**	2.52	5.06***	1.27	0					
7414	Bus. and man. consultancy activ.	2.16***	0.1	2.13***	0.06	0	2.16***	0.09	2.16***	0.09	0
7415	Man. activ. of holding companies	2.26***	0.09	2.15***	0.05	0	2.08***	0.09	2.09***	0.09	0
7420	Architectural, etc.	2.1***	0.05	2.07***	0.04	0	2.09***	0.03	2.1***	0.03	0
8000	Education	2.82***	0.06	2.85***	0.07	0	2.05***	0.03	2.06***	0.03	0
7599	Other	2.08***	0.04	2.06***	0.02	0	2.27***	0.04	2.28***	0.04	0

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 7. **Estimated mark-ups for services industries in Germany, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.										
4100	Collection, purification, etc.						1.79***	0.05	1.79***	0.05	0
4500	Construction						1.76***	0.05	1.76***	0.05	0
5000	Sale, maintenance, etc.										
5100	Wholesale trade, etc.						1.29***	0.04	1.29***	0.04	0
5200	Retail trade										
5500	Hotels and restaurants						2.04***	0.13	2.04***	0.13	0
6000	Land transport										
6100	Water transport										
6200	Air transport										
6300	Supporting, etc.	5.22***	0.24	5.02***	0.12	0	2.99***	0.15	2.98***	0.15	0
6410	Post and courier activ.										
6420	Telecommunications										
6500	Financial intermediation										
6700	Activ. auxiliary to fin. int.										
7000	Real estate										
7100	Renting										
7200	Computer activities	1.82***	0.06	1.78***	0.06	0					
7300	Research and development										
7400	Other business activ.										
7411	Legal activ.										
7412	Accounting, etc.										
7413	Market research, etc.										
7414	Bus. and man. consultancy activ.						2.03***	0.12	2.03***	0.12	0
7415	Man. activ. of holding companies	2.83***	0.23	2.69***	0.12	0	1.99***	0.17	1.99***	0.17	0
7420	Architectural, etc.						1.97***	0.13	1.97***	0.13	0
8000	Education										
7599	Other	2.39***	0.14	2.3***	0.08	0	2.36***	0.11	2.35***	0.11	0

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 8. **Estimated mark-ups for services industries in Greece, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.										
4100	Collection, purification, etc.						1.15***	0.07	1.14***	0.05	0
4500	Construction	1.5***	0.03	1.5***	0.02	0	1.39***	0.03	1.39***	0.03	0
5000	Sale, maintenance, etc.	1.25***	0.03	1.25***	0.02	0	1.29***	0.03	1.29***	0.03	0
5100	Wholesale trade, etc.	1.2***	0.01	1.2***	0	0	1.29***	0.01	1.29***	0.01	0
5200	Retail trade	1.22***	0.01	1.23***	0.02	0	1.45***	0.03	1.45***	0.03	0
5500	Hotels and restaurants	2.11***	0.04	2.09***	0.03	0	1.59***	0.04	1.57***	0.04	0
6000	Land transport						1.15***	0.02	1.15***	0.02	0
6100	Water transport						1.24***	0.05	1.23***	0.06	1
6200	Air transport						1***	0.06	1***	0.06	0
6300	Supporting, etc.	1.34***	0.02	1.34***	0.02	0	1.22***	0.02	1.22***	0.02	0
6410	Post and courier activ.										
6420	Telecommunications										
6500	Financial intermediation										
6700	Activ. auxiliary to fin. int.						3.13***	0.22	3.08***	0.22	0
7000	Real estate						2.42***	0.30	2.41***	0.30	0
7100	Renting	1.38***	0.08	1.34***	0.06	1	1.13***	0.10	1.12***	0.10	0
7200	Computer activities										
7300	Research and development										
7400	Other business activ.						1.38***	0.06	1.38***	0.06	0
7411	Legal activ.						1.29***	0	1.29***	0	0
7412	Accounting, etc.										
7413	Market research, etc.						1.47***	0.06	1.46***	0.06	0
7414	Bus. and man. consultancy activ.	1.55***	0.05	1.5***	0.04	0	1.44***	0.05	1.44***	0.05	0
7415	Man. activ. of holding companies										
7420	Architectural, etc.						1.36***	0.06	1.36***	0.06	0
8000	Education						0.91***	0.05	0.9***	0.05	0
7599	Other	2.02***	0.14	2.01***	0.11	0	1.56***	0.15	1.55***	0.15	0

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 9. **Estimated mark-ups for services industries in Hungary, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.						1.78***	0.2	1.73***	0.19	0
4100	Collection, purification, etc.										
4500	Construction						1.26***	0.03	1.26***	0.03	0
5000	Sale, maintenance, etc.										
5100	Wholesale trade, etc.						1.75***	0.04	1.73***	0.04	0
5200	Retail trade						1.65***	0.12	1.64***	0.11	0
5500	Hotels and restaurants										
6000	Land transport						1.47***	0.12	1.46***	0.12	0
6100	Water transport										
6200	Air transport										
6300	Supporting, etc.										
6410	Post and courier activ.										
6420	Telecommunications										
6500	Financial intermediation										
6700	Activ. auxiliary to fin. int.										
7000	Real estate						1.69***	0.11	1.68***	0.11	0
7100	Renting										
7200	Computer activities										
7300	Research and development										
7400	Other business activ.										
7411	Legal activ.						1.21***	0	1.2***	0	1
7412	Accounting, etc.						0.98***	0.1	0.99***	0.1	0
7413	Market research, etc.						0.54***	0	0.55***	0	0
7414	Bus. and man. consultancy activ.										
7415	Man. activ. of holding companies										
7420	Architectural, etc.										
8000	Education										
7599	Other						1.8***	0.18	1.79***	0.18	0

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 10. **Estimated mark-ups for services industries in Iceland, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.						0.43***	0	0.43***	0	0
4100	Collection, purification, etc.										
4500	Construction										
5000	Sale, maintenance, etc.										
5100	Wholesale trade, etc.										
5200	Retail trade										
5500	Hotels and restaurants						2.06***	0.09	2.06***	0.09	0
6000	Land transport										
6100	Water transport						4.79***	0.00	4.74***	0.00	0
6200	Air transport										
6300	Supporting, etc.										
6410	Post and courier activ.						1.35***	0.00	1.33***	0.00	0
6420	Telecommunications						5.4***	0.03	5.16***	0.01	1
6500	Financial intermediation										
6700	Activ. auxiliary to fin. int.										
7000	Real estate										
7100	Renting						2.34***	0.01	2.37***	0.03	1
7200	Computer activities										
7300	Research and development										
7400	Other business activ.						2.27***	0.04	2.18***	0.03	0
7411	Legal activ.										
7412	Accounting, etc.						1.41***	0	1.43***	0	0
7413	Market research, etc.										
7414	Bus. and man. consultancy activ.						3.52***	0.01	3.38***	0	0
7415	Man. activ. of holding companies										
7420	Architectural, etc.						1.85***	0.08	1.82***	0.08	0
8000	Education										
7599	Other										

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 11. **Estimated mark-ups for services industries in Italy, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.	1.78***	0.07	1.84***	0.05	0	2.06***	0.1	2.07***	0.1	0
4100	Collection, purification, etc.	2.07***	0.13	2.07***	0.08	0					
4500	Construction	2.43***	0.03	2.39***	0.02	0	2.35***	0.03	2.35***	0.03	0
5000	Sale, maintenance, etc.	1.39***	0.05	1.37***	0.03	0	1.27***	0.04	1.27***	0.04	0
5100	Wholesale trade, etc.	1.49***	0.01	1.49***	0.01	0	1.33***	0.01	1.33***	0.01	0
5200	Retail trade	1.45***	0.01	1.45***	0.01	0	1.3***	0.02	1.3***	0.02	0
5500	Hotels and restaurants	2.64***	0.13	2.58***	0.07	0	2.22***	0.12	2.23***	0.12	0
6000	Land transport	3.24***	0.09	3.21***	0.06	0	2.73***	0.07	2.73***	0.07	0
6100	Water transport	3.36***	0.34	3.3***	0.24	0	3.88***	0.29	3.9***	0.29	0
6200	Air transport										
6300	Supporting, etc.	3.05***	0.05	3.05***	0.03	0	3.11***	0.04	3.12***	0.04	0
6410	Post and courier activ.										
6420	Telecommunications	2.75***	0.35	2.81***	0.21	0	2.79***	0.23	2.78***	0.23	0
6500	Financial intermediation	2.82***	0.25	2.62***	0.18	0	2.91***	0.28	2.92***	0.28	0
6700	Activ. auxiliary to fin. int.	1.84***	0.08	1.9***	0.07	0	3.74***	0.07	3.76***	0.06	0
7000	Real estate	3.01***	0.1	3.01***	0.07	0	2.71***	0.09	2.71***	0.09	0
7100	Renting	2.21***	0.07	2.28***	0.06	0	2.22***	0.07	2.22***	0.07	0
7200	Computer activities	2.65***	0.05	2.6***	0.03	0	2.3***	0.04	2.3***	0.04	0
7300	Research and development	2.57***	0.16	2.53***	0.12	0	3.08***	0.13	3.08***	0.13	0
7400	Other business activ.	2.8***	0.05	2.83***	0.03	0	2.23***	0.04	2.23***	0.04	0
7411	Legal activ.										
7412	Accounting, etc.	2.69***	0.09	2.69***	0.07	0	2.41***	0.12	2.41***	0.12	0
7413	Market research, etc.	2.98***	0.09	2.93***	0.06	0	2.39***	0.06	2.4***	0.06	0
7414	Bus. and man. consultancy activ.	2.87***	0.1	2.77***	0.06	0	2.73***	0.09	2.73***	0.09	0
7415	Man. activ. of holding companies	1.71***	0.13	1.85***	0.12	0	2.07***	0.16	2.07***	0.16	0
7420	Architectural, etc.	2.99***	0.06	3.05***	0.05	0	2.65***	0.05	2.65***	0.05	0
8000	Education	3.24***	0.07	3.37***	0.09	0	3.3***	0.06	3.28***	0.06	0
7599	Other	3.04***	0.1	2.98***	0.06	0	2.76***	0.09	2.77***	0.09	0

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 12. **Estimated mark-ups for services industries in the Netherlands, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.										
4100	Collection, purification, etc.						4.02***	0.1	4.26***	0.11	0
4500	Construction						1.5***	0.02	1.49***	0.02	0
5000	Sale, maintenance, etc.										
5100	Wholesale trade, etc.						1.24***	0.01	1.24***	0.01	0
5200	Retail trade										
5500	Hotels and restaurants						1.77***	0.08	1.86***	0.11	0
6000	Land transport						1.57***	0.06	1.69***	0.08	0
6100	Water transport										
6200	Air transport										
6300	Supporting, etc.										
6410	Post and courier activ.										
6420	Telecommunications										
6500	Financial intermediation										
6700	Activ. auxiliary to fin. int.										
7000	Real estate										
7100	Renting						1.51***	0.00	1.45***	0.00	0
7200	Computer activities										
7300	Research and development						1.59***	0.00	1.63***	0.00	0
7400	Other business activ.										
7411	Legal activ.										
7412	Accounting, etc.										
7413	Market research, etc.										
7414	Bus. and man. consultancy activ.										
7415	Man. activ. of holding companies						2.42***	0.01	2.48***	0.01	0
7420	Architectural, etc.										
8000	Education										
7599	Other										

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 13. **Estimated mark-ups for services industries in Norway, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.	2.68***	0.21	2.61***	0.19	0	2.29***	0.14	2.29***	0.14	0
4100	Collection, purification, etc.										
4500	Construction	1.35***	0.01	1.34***	0.01	0	1.32***	0.01	1.32***	0.01	0
5000	Sale, maintenance, etc.	1.26***	0.01	1.26***	0	0					
5100	Wholesale trade, etc.	1.26***	0.01	1.26***	0.01	0	1.28***	0.01	1.28***	0.01	0
5200	Retail trade	1.16***	0.01	1.16***	0.01	0	1.24***	0.01	1.24***	0.01	0
5500	Hotels and restaurants	1.41***	0.03	1.39***	0.02	0	1.68***	0.03	1.68***	0.03	0
6000	Land transport	2.02***	0.02	2***	0.02	0					
6100	Water transport										
6200	Air transport										
6300	Supporting, etc.	1.57***	0.02	1.58***	0.02	0					
6410	Post and courier activ.										
6420	Telecommunications	1.48***	0.05	1.62***	0.06	0	1.37***	0.05	1.37***	0.05	0
6500	Financial intermediation	1.13***	0.05	1.23***	0.14	1					
6700	Activ. auxiliary to fin. int.						1.99***	0.12	2***	0.12	0
7000	Real estate	2.43***	0.07	2.39***	0.05	0	1.81***	0.08	1.82***	0.08	0
7100	Renting	1.58***	0.04	1.57***	0.04	0	1.65***	0.04	1.65***	0.04	0
7200	Computer activities	1.62***	0.05	1.6***	0.04	0	1.62***	0.04	1.62***	0.04	0
7300	Research and development	3.17***	0.4	3.05***	0.27	0					
7400	Other business activ.	1.73***	0.07	1.7***	0.04	0	1.57***	0.07	1.57***	0.07	0
7411	Legal activ.										
7412	Accounting, etc.	1.52***	0.12	1.59***	0.17	0					
7413	Market research, etc.										
7414	Bus. and man. consultancy activ.	1.67***	0.05	1.67***	0.04	0	1.48***	0.02	1.48***	0.02	0
7415	Man. activ. of holding companies										
7420	Architectural, etc.	1.63***	0.04	1.6***	0.03	0	1.49***	0.03	1.49***	0.03	0
8000	Education	2.21***	0.04	2.23***	0.02	0					
7599	Other	1.87***	0.03	1.85***	0.02	0	1.83***	0.04	1.83***	0.04	0

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 14. **Estimated mark-ups for services industries in Poland, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.	6.99***	0.13	6.85***	0.17	0	1.68***	0.1	1.7***	0.1	0
4100	Collection, purification, etc.	12.85***	0.08	12.92***	0.06	0	1.93***	0.1	1.95***	0.11	0
4500	Construction	4.83***	0.21	4.63***	0.11	0	2.72***	0.17	2.74***	0.17	0
5000	Sale, maintenance, etc.						1.73***	0.12	1.74***	0.12	0
5100	Wholesale trade, etc.	5.66***	0.05	5.64***	0.04	0	1.6***	0.04	1.61***	0.04	0
5200	Retail trade	4.03***	0.27	4.1***	0.19	0	1.77***	0.16	1.78***	0.16	0
5500	Hotels and restaurants										
6000	Land transport	4.82***	0.15	4.84***	0.1	0	2.05***	0.08	2.06***	0.08	0
6100	Water transport										
6200	Air transport										
6300	Supporting, etc.	4.1***	0.11	4.27***	0.11	0	2.97***	0.11	2.99***	0.11	0
6410	Post and courier activ.										
6420	Telecommunications										
6500	Financial intermediation	3.46***	0.45	3.55***	0.36	0					
6700	Activ. auxiliary to fin. int.										
7000	Real estate	3.07***	0.12	3.08***	0.08	0	2.43***	0.21	2.44***	0.21	0
7100	Renting										
7200	Computer activities	4.66***	0.4	4.47***	0.28	0					
7300	Research and development	9.3***	0.19	9.13***	0.16	0	1.94***	0.13	1.95***	0.13	0
7400	Other business activ.	2.78***	0.12	2.65***	0.07	0	2.4***	0.12	2.41***	0.12	0
7411	Legal activ.										
7412	Accounting, etc.										
7413	Market research, etc.						2.32***	0.11	2.32***	0.11	0
7414	Bus. and man. consultancy activ.										
7415	Man. activ. of holding companies										
7420	Architectural, etc.	4.27***	0.36	3.98***	0.22	0					
8000	Education						1.69***	0.09	1.71***	0.09	0
7599	Other						2.21***	0.19	2.22***	0.19	0

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 15. **Estimated mark-ups for services industries in Portugal, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.						1.98***	0.09	2***	0.1	0
4100	Collection, purification, etc.										
4500	Construction	2***	0.05	1.96***	0.04	0	2.43***	0.04	2.43***	0.04	0
5000	Sale, maintenance, etc.						7.91***	0.09	7.91***	0.09	0
5100	Wholesale trade, etc.						5.13***	0.10	5.15***	0.10	0
5200	Retail trade						5.67***	0.08	5.71***	0.08	0
5500	Hotels and restaurants						2.54***	0.18	2.57***	0.19	0
6000	Land transport						1.88***	0.05	1.91***	0.05	0
6100	Water transport						5.76***	0.14	5.74***	0.14	0
6200	Air transport										
6300	Supporting, etc.										
6410	Post and courier activ.						2.13***	0.00	2.09***	0.00	0
6420	Telecommunications										
6500	Financial intermediation										
6700	Activ. auxiliary to fin. int.										
7000	Real estate						2.85***	0.21	2.86***	0.21	0
7100	Renting										
7200	Computer activities						1.9***	0.03	1.92***	0.04	0
7300	Research and development										
7400	Other business activ.										
7411	Legal activ.										
7412	Accounting, etc.						2.01***	0	2.01***	0	0
7413	Market research, etc.										
7414	Bus. and man. consultancy activ.										
7415	Man. activ. of holding companies						3.09***	0.17	3.16***	0.17	0
7420	Architectural, etc.										
8000	Education										
7599	Other						2.8***	0.14	2.83***	0.15	0

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 16. **Estimated mark-ups for services industries in the Slovak Republic, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.						1.33***	0.04	1.33***	0.04	0
4100	Collection, purification, etc.										
4500	Construction						2.59***	0.08	2.59***	0.08	0
5000	Sale, maintenance, etc.						8.02***	0.22	7.99***	0.21	0
5100	Wholesale trade, etc.	3.89***	0.1	4***	0.06	0	5.81***	0.10	5.81***	0.10	0
5200	Retail trade										
5500	Hotels and restaurants						1.77***	0.05	1.77***	0.05	0
6000	Land transport						2.17***	0.02	2.17***	0.02	0
6100	Water transport										
6200	Air transport										
6300	Supporting, etc.										
6410	Post and courier activ.										
6420	Telecommunications										
6500	Financial intermediation										
6700	Activ. auxiliary to fin. int.										
7000	Real estate						2.85***	0.11	2.85***	0.11	0
7100	Renting						4.57***	0.18	4.57***	0.18	0
7200	Computer activities						3.68***	0.14	3.68***	0.14	0
7300	Research and development										
7400	Other business activ.						2.52***	0.07	2.52***	0.07	0
7411	Legal activ.										
7412	Accounting, etc.										
7413	Market research, etc.										
7414	Bus. and man. consultancy activ.										
7415	Man. activ. of holding companies										
7420	Architectural, etc.										
8000	Education						2.31***	0.06	0***	0.06	0
7599	Other	5.6***	0.29	6.1***	0.28	0					

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 17. **Estimated mark-ups for services industries in Spain, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.	1.89***	0.1	1.92***	0.12	0	1.88***	0.11	1.89***	0.11	0
4100	Collection, purification, etc.						1.58***	0.06	1.58***	0.06	0
4500	Construction	1.35***	0.01	1.35***	0	0	1.25***	0.01	1.25***	0.01	0
5000	Sale, maintenance, etc.	1.22***	0.01	1.22***	0	0	1.13***	0.01	1.14***	0.01	0
5100	Wholesale trade, etc.	1.27***	0	1.26***	0	0	1.17***	0.00	1.18***	0.00	0
5200	Retail trade	1.21***	0.01	1.2***	0.01	0	1.21***	0.01	1.21***	0.01	0
5500	Hotels and restaurants	1.53***	0.02	1.52***	0.01	0	1.71***	0.03	1.72***	0.03	0
6000	Land transport	1.82***	0.02	1.83***	0.02	0	1.51***	0.02	1.52***	0.02	0
6100	Water transport	2.4***	0.06	2.43***	0.07	0					
6200	Air transport										
6300	Supporting, etc.	1.79***	0.04	1.77***	0.03	0	1.36***	0.03	1.36***	0.03	0
6410	Post and courier activ.	1.78***	0.02	1.8***	0.02	0	1.27***	0.01	1.27***	0.02	0
6420	Telecommunications	1.43***	0.05	1.44***	0.05	0	1.5***	0.04	1.5***	0.04	0
6500	Financial intermediation	1.68***	0.33	1.69***	0.22	1					
6700	Activ. auxiliary to fin. int.	2.16***	0.11	2.08***	0.08	0	1.98***	0.11	1.98***	0.11	0
7000	Real estate	2***	0.02	1.94***	0.01	0	1.79***	0.02	1.79***	0.02	0
7100	Renting	1.62***	0.03	1.61***	0.03	0	1.69***	0.02	1.69***	0.02	0
7200	Computer activities	1.44***	0.03	1.45***	0.03	0	1.43***	0.02	1.43***	0.02	0
7300	Research and development	2.09***	0.14	2.02***	0.11	0	2***	0.16	2***	0.16	0
7400	Other business activ.	1.67***	0.02	1.66***	0.01	0	1.35***	0.01	1.35***	0.01	0
7411	Legal activ.	1.46***	0.18	1.56***	0.18	1					
7412	Accounting, etc.	2.08***	0.13	1.97***	0.08	0	2.09***	0.14	2.09***	0.14	0
7413	Market research, etc.	1.83***	0.07	1.87***	0.07	0	1.57***	0.05	1.57***	0.05	0
7414	Bus. and man. consultancy activ.	2.25***	0.12	2.22***	0.08	0	1.83***	0.09	1.83***	0.1	0
7415	Man. activ. of holding companies	2.13***	0.14	2.24***	0.15	0	2.02***	0.15	2.02***	0.15	0
7420	Architectural, etc.	1.72***	0.07	1.69***	0.04	0	1.55***	0.04	1.55***	0.04	0
8000	Education	2.05***	0.06	2.01***	0.04	0	1.74***	0.05	1.74***	0.05	0
7599	Other	1.75***	0.02	1.75***	0.02	0	1.81***	0.02	1.82***	0.02	0

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 18. **Estimated mark-ups for services industries in Sweden, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.						2.71***	0.27	0***	0.3	0
4100	Collection, purification, etc.										
4500	Construction	2.07***	0.05	1.99***	0.03	0	2.03***	0.02	2.06***	0.02	0
5000	Sale, maintenance, etc.	2***	0.05	1.95***	0.04	0	1.72***	0.05	1.73***	0.06	0
5100	Wholesale trade, etc.	2.24***	0.04	2.17***	0.03	0	1.91***	0.03	1.93***	0.03	0
5200	Retail trade	1.87***	0.04	1.82***	0.03	0	1.73***	0.03	1.75***	0.03	0
5500	Hotels and restaurants	1.78***	0.04	1.7***	0.03	0	2.44***	0.03	2.49***	0.03	0
6000	Land transport	2.24***	0.08	2.28***	0.07	0	2.3***	0.06	2.38***	0.06	0
6100	Water transport										
6200	Air transport						1.7***	0.09	1.71***	0.09	0
6300	Supporting, etc.	3.13***	0.26	3.01***	0.2	0	2.55***	0.17	2.61***	0.18	0
6410	Post and courier activ.										
6420	Telecommunications	1.71***	0.2	1.72***	0.16	1	2.72***	0.25	2.74***	0.25	0
6500	Financial intermediation										
6700	Activ. auxiliary to fin. int.						1.81***	0.12	1.81***	0.13	0
7000	Real estate	2.84***	0.1	2.71***	0.07	0	2.39***	0.08	2.42***	0.08	0
7100	Renting	1.98***	0.12	1.91***	0.09	0	2.46***	0.08	2.53***	0.09	0
7200	Computer activities	2.15***	0.11	2.04***	0.07	0	2.21***	0.06	2.24***	0.06	0
7300	Research and development										
7400	Other business activ.	2.25***	0.12	2.17***	0.08	0	2.21***	0.05	2.26***	0.06	0
7411	Legal activ.										
7412	Accounting, etc.						2.01***	0.15	0***	0.15	0
7413	Market research, etc.										
7414	Bus. and man. consultancy activ.	2.06***	0.09	2.04***	0.07	0	2.01***	0.06	2.03***	0.06	0
7415	Man. activ. of holding companies	2.68***	0.15	2.42***	0.11	0	2.47***	0.11	2.52***	0.11	0
7420	Architectural, etc.	2.53***	0.25	2.3***	0.15	0	2.72***	0.17	2.77***	0.17	0
8000	Education						2.28***	0.12	2.33***	0.13	0
7599	Other	2.32***	0.13	2.19***	0.09	0	2.49***	0.07	2.55***	0.07	0

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 19. **Estimated mark-ups for services industries in Switzerland, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.										
4100	Collection, purification, etc.										
4500	Construction						1.49***	0.01	0***	0.01	0
5000	Sale, maintenance, etc.						0.93***	0	1.04***	0	0
5100	Wholesale trade, etc.										
5200	Retail trade						1.2***	0.05	1.21***	0.05	0
5500	Hotels and restaurants						1.76***	0.13	1.78***	0.12	0
6000	Land transport						2.31***	0.17	2.32***	0.18	0
6100	Water transport						1.03***	0.00	1.03***	0.00	1
6200	Air transport						1.87***	0.12	1.88***	0.14	0
6300	Supporting, etc.						1.59***	0.00	1.59***	0.00	0
6410	Post and courier activ.										
6420	Telecommunications										
6500	Financial intermediation										
6700	Activ. auxiliary to fin. int.										
7000	Real estate										
7100	Renting										
7200	Computer activities						1.8***	0.17	1.77***	0.17	0
7300	Research and development										
7400	Other business activ.										
7411	Legal activ.										
7412	Accounting, etc.										
7413	Market research, etc.						1.22***	0	1.23***	0	0
7414	Bus. and man. consultancy activ.						0.89***	0	0.88***	0	1
7415	Man. activ. of holding companies						1.47***	0.04	1.48***	0.05	0
7420	Architectural, etc.										
8000	Education						1.5***	0	1.47***	0	0
7599	Other	1.09***	0.05	1.1***	0.06	1	1.45***	0.06	1.46***	0.06	0

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 20. **Estimated mark-ups for services industries in the United Kingdom, 1993-2006**

NACE	Sectors	Ordinary least squares					Computation				
		FE_yd	se	OLS_yd	se	CRS	yd	se	trend	se	CRS
4000	Electricity, gas, etc.						1.43***	0.11	1.44***	0.11	0
4100	Collection, purification, etc.						1.09*	0.05	1.1*	0.05	1
4500	Construction	1.27***	0.02	1.26***	0.01	0	1.16***	0.03	1.16***	0.03	0
5000	Sale, maintenance, etc.	1.15***	0.02	1.15***	0.01	0	1.12***	0.02	1.12***	0.02	0
5100	Wholesale trade, etc.	1.19***	0.01	1.19***	0.01	0	1.2***	0.01	1.21***	0.01	0
5200	Retail trade	1.17***	0.02	1.17***	0.02	0	1.32***	0.02	1.32***	0.02	0
5500	Hotels and restaurants	1.24***	0.02	1.24***	0.01	0	1.41***	0.03	1.42***	0.03	0
6000	Land transport	1.19***	0.01	1.18***	0.01	0	0.97***	0.01	0.97***	0.01	0
6100	Water transport	1.53***	0.06	1.59***	0.04	0					
6200	Air transport	1.11***	0.04	1.1***	0.03	1	1.15**	0.06	1.15**	0.06	1
6300	Supporting, etc.						1.17***	0.03	1.18***	0.03	0
6410	Post and courier activ.										
6420	Telecommunications						1.44***	0.09	1.44***	0.09	0
6500	Financial intermediation	1.32***	0.05	1.35***	0.04	0	1.54***	0.06	1.54***	0.06	0
6700	Activ. auxiliary to fin. int.						1.38***	0.04	1.38***	0.04	0
7000	Real estate	2.02***	0.07	1.92***	0.04	0	1.83***	0.07	1.83***	0.07	0
7100	Renting	1.2***	0.02	1.2***	0.01	0	1.12***	0.04	1.12***	0.03	0
7200	Computer activities	1.32***	0.02	1.33***	0.02	0	1.41***	0.03	1.41***	0.03	0
7300	Research and development						1.58***	0.20	1.59***	0.20	0
7400	Other business activ.	1.28***	0.01	1.29***	0.01	0	1.19***	0.02	1.19***	0.02	0
7411	Legal activ.										
7412	Accounting, etc.										
7413	Market research, etc.	1.44***	0.03	1.44***	0.03	0	1.27***	0.02	1.28***	0.02	0
7414	Bus. and man. consultancy activ.	1.34***	0.03	1.32***	0.03	0	1.2***	0.05	1.2***	0.05	0
7415	Man. activ. of holding companies	1.31***	0.04	1.3***	0.03	0	1.34***	0.06	1.34***	0.06	0
7420	Architectural, etc.	1.39***	0.03	1.39***	0.02	0	1.01***	0.02	1.01***	0.02	0
8000	Education	1.34***	0.03	1.34***	0.03	0	1.05***	0.04	1.05***	0.04	0
7599	Other	1.34***	0.02	1.34***	0.02	0	1.26***	0.04	1.26***	0.04	0

Note: In the left-hand side of the panel, input coefficients of the production function were estimated using ordinary least squares, while mark-ups were estimated using both fixed effects with year dummies and no fixed effects but with year dummies. In the right-hand side of the panel, the input coefficients were computed and the mark-ups estimated with year dummies and with a time trend, respectively. Standard errors (se) were computed by the delta method. CRS indicates whether there are constant returns to scale in the sector (1 = yes, 0 = no).
Source: Authors' estimation.

Table 21. **Statistics for the regressions estimating the mark-ups**

	Ordinary least squares				Computation			
	Non-constant returns to scale		Constant returns to scale		Non-constant returns to scale		Constant returns to scale	
	Fixed effect	Without fixed effects	Fixed effect	Without fixed effects	With year dummies	With time trend	With year dummies	With time trend
dummy_1995	0.00	0.00	–0.01	–0.0192***	0.00		–0.0200***	
	–0.90	*–0.88*	*–0.15*	*–0.01*	*–0.56*		*0.00*	
dummy_1996	–0.02***	–0.02***	–0.02***	–0.03***	–0.02***		–0.02***	
	0.00	*0.00*	*–0.01*	*0.00*	*0.00*		*–0.01*	
dummy_1997	–0.02***	–0.02***	–0.01*	–0.03***	–0.02***		–0.02**	
	0.00	*0.00*	*–0.05*	*0.00*	*0.00*		*–0.02*	
dummy_1998	0.01**	0.02**	0.03***	0.02**	–0.01		0.02**	
	–0.03	*–0.02*	*0.00*	*–0.02*	*–0.14*		*–0.02*	
dummy_1999	–0.06***	–0.06***	–0.08***	–0.10***	–0.07***		–0.09***	
	0	*0*	*0*	*0*	*0*		*0*	
dummy_2000	0.01	0.00	0.01	–0.02**	0		0	
	–0.44	*–0.62*	*–0.46*	*–0.01*	*–0.64*		*–0.61*	
dummy_2001	–0.01*	–0.01*	0	–0.02***	–0.01		0	
	–0.07	*–0.08*	*–0.83*	*0*	*–0.20*		*–0.80*	
dummy_2002	–0.02***	–0.02**	0	–0.02***	–0.02***		0	
	0	*–0.01*	*–0.92*	*0*	*–0.01*		*–0.70*	
dummy_2003	–0.03***	–0.03***	–0.01	–0.03***	–0.03***		–0.01	
	0.00	*0.00*	*–0.48*	*0.00*	*0.00*		*–0.36*	
dummy_2004	–0.02**	–0.01	0.01	–0.02***	–0.02***		0	
	–0.01	*–0.35*	*–0.40*	*–0.01*	*0*		*–0.99*	
dummy_2005	–0.03***	–0.02***	0	–0.03***	–0.03***		0	
	0	*0*	*–0.85*	*0*	*0*		*–0.68*	
dummy_2006	–0.02**	–0.02***	0.01	–0.03***	0		0.01	
	–0.05	*–0.01*	*–0.54*	*0*	*–0.76*		*–0.52*	
trend						0		0.00***
						–0.56		*0*
Constant	0.04***	0.04***	0.00	0.02***	0.02***	0.00***	–0.02***	–0.06***
	–4.18E-09	*–2.55E-08*	*–0.86*	*0.00*	*–4.9E–05*	*0.00*	*0.00*	*0*
No. of observations	2 201 500	2 201 500	2 260 325	2 260 325	2 315 304	2 315 304	2 327 854	2 327 854
No. of firms	390 903		408 612		428 956	428 956	430 588	430 588
R-squared	0.23	0.22	0.21	0.21	0.14	0.13	0.12	0.11
F-test all u_i = 0	0.95		0.83		1.60	1.59	1.16	1.15
p-value	0		0		0	0	0	0
Wald test for heteroskedasticity	3.70E + 41		6.40E + 43					
p-value	0		0		0	0	0	0

*, **, *** indicate significance at the 1%, 5% and 10% levels, respectively; standard errors are in italics. These statistics should be viewed in conjunction with the country- and sector-specific coefficients in Tables 1-20.

Table 22. **Results for testing the equality of Lerner indices across countries**

NACE	Sector	OLS fixed effects		Computed coefficients	
40	Electricity, gas, etc.	F(11.408611)	366.34	F(20.430587)	10 136.57
		Prob > F	*0*	*Prob > F*	*0*
41	Water collection, purification, etc.	F(4.408611)	1 524.16	F(17.430587)	85.81
		Prob > F	*0*	*Prob > F*	*0*
45	Construction	F(15.408611)	589.34	F(20.430587)	112.17
		Prob > F	*0*	*Prob > F*	*0*
50	Sale, maintenance, etc.	F(11.408611)	175.26	F(20.430587)	279.48
		Prob > F	*0*	*Prob > F*	*0*
51	Wholesale trade, etc.	F(13.408611)	399.59	F(20.430587)	70.3
		Prob > F	*0*	*Prob > F*	*0*
52	Retail trade	F(13.408611)	65.51	F(20.430587)	26.55
		Prob > F	*0*	*Prob > F*	*0*
55	Hotels and restaurants	F(12.408611)	96.28	F(20.430587)	64.96
		Prob > F	*0*	*Prob > F*	*0*
60	Land transport	F(10.408611)	272.9	F(20.430587)	36.46
		Prob > F	*0*	*Prob > F*	*0*
61	Water transport	F(6.408611)	32.17	F(19.430587)	1.20E+05
		Prob > F	*0*	*Prob > F*	*0*
62	Air transport	F(2.408611)	11.42	F(19.430587)	505.03
		Prob > F	*0*	*Prob > F*	*0*
63	Supporting, etc.	F(13.408611)	126.88	F(20.430587)	1 337.78
		Prob > F	*0*	*Prob > F*	*0*
641	Post and courier activ.	F(2.408611)	149.18	F(15.430587)	4 395.88
		Prob > F	*0*	*Prob > F*	*0*
642	Telecommunications	F(6.408611)	120.63	F(17.430587)	47 659.26
		Prob > F	*0*	*Prob > F*	*0*
65	Financial intermediation	F(9.408611)	47.18	F(17.430587)	20.28
		Prob > F	*0*	*Prob > F*	*0*
67	Activ. auxiliary to fin. int.	F(7.408611)	56.49	F(17.430587)	203.96
		Prob > F	*0*	*Prob > F*	*0*
70	Real estate	F(13.408611)	377.16	F(19.430587)	97
		Prob > F	*0*	*Prob > F*	*0*
71	Renting	F(9.408611)	100.8	F(19.430587)	5 660.55
		Prob > F	*0*	*Prob > F*	*0*
72	Computer activities	F(12.408611)	172.42	F(20.430587)	36.31
		Prob > F	*0*	*Prob > F*	*0*
73	Research and development	F(5.408611)	184.94	F(17.430587)	227.62
		Prob > F	*0*	*Prob > F*	*0*
74	Other business activ.	F(12.408611)	218.7	F(20.430587)	74.32
		Prob > F	*0*	*Prob > F*	*0*
7411	Legal activ.	F(2.408611)	9.7	F(13.430587)	4 271.35
		Prob > F	*0.0001*	*Prob > F*	*0*
7412	Accounting, etc.	F(7.408611)	46.12	F(17.430587)	1 619.94
		Prob > F	*0*	*Prob > F*	*0*
7413	Market research, etc.	F(4.408611)	80.2	F(16.430587)	1 501.7
		Prob > F	*0*	*Prob > F*	*0*
7414	Bus. and man. consultancy activ.	F(10.408611)	73.79	F(18.430587)	31 074.11
		Prob > F	*0*	*Prob > F*	*0*
7415	Man. activ. of holding companies	F(10.408611)	62.33	F(20.430587)	255.25
		Prob > F	*0*	*Prob > F*	*0*
7420	Architectural, etc.	F(12.408611)	133.37	F(19.430587)	24.1
		Prob > F	*0*	*Prob > F*	*0*
7599	Other	F(15.408611)	142.87	F(20.430587)	50.87
		Prob > F	*0*	*Prob > F*	*0*
80	Education	F(10.408611)	67.68	F(17.430587)	769.53
		Prob > F	*0*	*Prob > F*	*0*

Note: Applying the F-test to check whether the Lerner indices, obtained for different countries in the same sector, are the same when using input coefficients estimated by OLS with fixed effects and computed input coefficients.

Table 23. **Results for testing the equality of Lerner indices across sectors**

	OLS fixed effects		Computed coefficients	
AUT	F(0.408611)	. .	F(19.430587)	3 758.85
	Prob > F	. .	*Prob > F*	*0*
BEL	F(17.408611)	37.56	F(27.430587)	6.28
	Prob > F	*0*	*Prob > F*	*0*
CHE	F(3.408611)	33.32	F(17.430587)	5 627.61
	Prob > F	*0*	*Prob > F*	*0*
CZE	F(14.408611)	64.92	F(27.430587)	53.75
	Prob > F	*0*	*Prob > F*	*0*
DEU	F(8.408611)	69.44	F(27.430587)	17.38
	Prob > F	*0*	*Prob > F*	*0*
DNK	F(10.408611)	18.42	F(27.430587)	5.03
	Prob > F	*0*	*Prob > F*	*0*
ESP	F(27.408611)	293.08	F(27.430587)	31.14
	Prob > F	*0*	*Prob > F*	*0*
FIN	F(21.408611)	49.92	F(27.430587)	6.62
	Prob > F	*0*	*Prob > F*	*0*
FRA	F(24.408611)	397.65	F(27.430587)	18
	Prob > F	*0*	*Prob > F*	*0*
GBR	F(21.408611)	50.9	F(27.430587)	10.15
	Prob > F	*0*	*Prob > F*	*0*
GRC	F(16.408611)	62.22	F(25.430587)	611.05
	Prob > F	*0*	*Prob > F*	*0*
HUN	F(0.408611)	. .	F(27.430587)	789.74
	Prob > F	. .	*Prob > F*	*0*
IRL	F(0.408611)	. .	F(1.430587)	239.9
	Prob > F	. .	*Prob > F*	*0*
ISL	F(0.408611)	. .	F(22.430587)	1.70E + 07
	Prob > F	. .	*Prob > F*	*0*
ITA	F(27.408611)	179.86	F(27.430587)	12.05
	Prob > F	*0*	*Prob > F*	*0*
NLD	F(0.408611)	. .	F(21.430587)	1 199.74
	Prob > F	. .	*Prob > F*	*0*
NOR	F(21.408611)	78.71	F(27.430587)	20.37
	Prob > F	*0*	*Prob > F*	*0*
POL	F(20.408611)	800.39	F(27.430587)	8.92
	Prob > F	*0*	*Prob > F*	*0*
PRT	F(1.408611)	376.43	F(24.430587)	2 010.59
	Prob > F	*0*	*Prob > F*	*0*
SVK	F(7.408611)	79.81	F(24.430587)	29.69
	Prob > F	*0*	*Prob > F*	*0*
SWE	F(18.408611)	333.17	F(27.430587)	4.11
	Prob > F	*0*	*Prob > F*	*0*

Note: Applying the F-test to check whether the Lerner indices, obtained for different countries in the same sector, are the same when using input coefficients estimated by OLS with fixed effects and computed input coefficients.

Table 24. **Testing of constant returns to scale for the OLS model with fixed effects**

NACE	Sector	AUT	BEL	CHE	CZE	DEU	DNK	ESP	FIN	FRA	GBR	GRC
40	Electricity, gas, etc.	0.31	0.2	53.1	3.79	4.6	2.18	4.24	60.56	7.69	13.53	0.57
		0.5758	*0.6566*	*0*	*0.0516*	*0.032*	*0.1399*	*0.0395*	*0*	*0.0056*	*0.0002*	*0.4522*
41	Water collection,	85 021.67	41.83	. .	33.37	0.18	1.24	6.09	8.21	20.14	14.5	22.67
	purification, etc.	*0*	*0*	. .	*0*	*0.6716*	*0.2657*	*0.0136*	*0.0042*	*0*	*0.0001*	*0*
45	Construction	7.26	41.99	0	43.72	45.02	46.08	1 786.38	152.59	704.68	123.95	62.95
		0.0071	*0*	*0.9609*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
50	Sale, maintenance, etc.	0.71	37.42	20 632.73	41.77	1.38	20.78	462.51	34.78	436.33	147.03	47.51
		0.3986	*0*	*0*	*0*	*0.2408*	*0*	*0*	*0*	*0*	*0*	*0*
51	Wholesale trade, etc.	0.66	199.48	2.6	264.25	22.71	15.99	1 395.55	157.18	1 263.39	183.55	151.28
		0.415	*0*	*0.1069*	*0*	*0*	*0.0001*	*0*	*0*	*0*	*0*	*0*
52	Retail trade	0	26.42	13.72	21.07	12.81	12.25	396.72	48.51	400.89	44.65	4.19
		0.9645	*0*	*0.0002*	*0*	*0.0003*	*0.0005*	*0*	*0*	*0*	*0*	*0.0406*
55	Hotels and restaurants	30.39	1.78	0.74	17.51	0.07	2.98	217.6	21.76	180.43	40.56	125.8
		0	*0.1821*	*0.39*	*0*	*0.7974*	*0.0842*	*0*	*0*	*0*	*0*	*0*
60	Land transport	1.32	67.65	0.84	27.72	0.16	1.69	385.02	45.44	340.88	73.31	5.84
		0.2513	*0*	*0.3606*	*0*	*0.6892*	*0.1942*	*0*	*0*	*0*	*0*	*0.0157*
61	Water transport	78.85	1.49	10 194.62	38.71	8.56	0.15	45.54	3.41	17.64	29.27	4.34
		0	*0.2216*	*0*	*0*	*0.0034*	*0.6996*	*0*	*0.0648*	*0*	*0*	*0.0373*
62	Air transport	138.16	0.06	5 354.01	72.36	4.45	9.92	0.55	0.18	1.37	0.81	3.82
		0	*0.8116*	*0*	*0*	*0.0349*	*0.0016*	*0.4591*	*0.6737*	*0.2415*	*0.3691*	*0.0507*
63	Supporting, etc.	43.98	11.29	33 194.61	25.16	78.76	7.07	200.94	29.46	98.87	28.65	14
		0	*0.0008*	*0*	*0*	*0*	*0.0078*	*0*	*0*	*0*	*0*	*0.0002*
641	Post and courier activ.	1 273.07	6.49	. .	18.31	26.53	0.47	23.67	123.27	7.82	14.88	30.19
		0	*0.0108*	. .	*0*	*0*	*0.4922*	*0*	*0*	*0.0052*	*0.0001*	*0*
642	Telecommunications	90 897.11	2.38	. .	16.56	0.32	0.29	7.38	0.1	1.69	0.08	1.18
		0	*0.1232*	. .	*0*	*0.572*	*0.5894*	*0.0066*	*0.7575*	*0.1937*	*0.7741*	*0.2772*
65	Financial	1.10E + 05	23.77	1.70E + 06	3.26	0.07	3.81	1.2	13.94	0.52	6.75	7.78
	intermediation	*0*	*0*	*0*	*0.071*	*0.7944*	*0.0508*	*0.2736*	*0.0002*	*0.4688*	*0.0094*	*0.0053*
67	Activ. auxiliary	0.08	14.12	. .	1.61	16.75	0.66	11.05	0.81	0.31	6.11	7.14
	to fin. int.	*0.7758*	*0.0002*	. .	*0.2045*	*0*	*0.4174*	*0.0009*	*0.3692*	*0.5759*	*0.0135*	*0.0076*
70	Real estate	6.61	56.3	336.37	34.46	11.18	2.27	540.72	35.42	206.23	93.04	21.56
		0.0101	*0*	*0*	*0*	*0.0008*	*0.1316*	*0*	*0*	*0*	*0*	*0*
71	Renting	1.15	17.03	. .	0.07	4.01	5.28	29.04	10.26	64.37	27.98	1.56
		0.2846	*0*	. .	*0.796*	*0.0452*	*0.0216*	*0*	*0.0014*	*0*	*0*	*0.2119*
72	Computer activities	0.37	36.65	17.42	87.82	16.63	9.9	32.29	0	132.26	13.18	7.65
		0.5405	0	0	0	0	0.0017	0	0.9572	0	0.0003	0.0057
73	Research	0.27	0.19	. .	7.08	5.08	3.23	11.05	2.53	5.83	0.34	. .
	and development	0.6022	0.6608	. .	0.0078	0.0242	0.0723	0.0009	0.112	0.0158	0.5588	. .
74	Other business activ.	10.22	49.51	10.57	37.38	41.9	12.18	257.69	38.13	308.24	91.63	15.17
		0.0014	0	0.0011	0	0	0.0005	0	0	0	0	0.0001
7411	Legal activ.	. .	20.81	. .	4.77	. .	14.6	0.24	5.7	4.53	0.35	17 244.49
		. .	0	. .	0.0289	. .	0.0001	0.6216	0.017	0.0333	0.5522	0
7412	Accounting, etc.	. .	5.21	. .	11.71	125.5	5.52	18.67	4.68	22.82	22.91	4.09
		. .	0.0224	. .	0.0006	0	0.0188	0	0.0305	0	0	0.0432
7413	Market research, etc.	. .	16.37	5.77	4.42	35.89	2.09	13.2	9.06	10.79	16.77	6.16
		. .	0.0001	0.0163	0.0356	0	0.1484	0.0003	0.0026	0.001	0	0.013
7414	Bus. and man.	. .	20.69	10 440.9	1.86	7.38	3.69	26.42	4.5	49.48	70.83	10.59
	consultancy activ.	. .	0	0	0.1731	0.0066	0.0546	0	0.0338	0	0	0.0011
7415	Man. activ. of holding	0.3	22.07	19.73	0.28	48.72	4.92	11.46	0.48	212.73	20.66	30.69
	companies	0.5822	0	0	0.5998	0	0.0265	0.0007	0.4881	0	0	0
7420	Architectural, etc.	0.04	2.74	4.00E + 05	61.33	17.75	0.75	55.39	30.28	60.74	38.96	17.04
		0.8393	0.0977	0	0	0	0.3857	0	0	0	0	0
80	Education	. .	6.29	1.70E+05	48.76	0.74	2.21	57.93	27.11	89.13	23.67	3.37
		. .	0.0121	0	0	0.3891	0.1369	0	0	0	0	0.0665
7599	Other	4.46	33.02	1.01	45.47	7.96	6.62	200.36	26.15	324.72	83.91	13.52
		0.0347	0	0.3155	0	0.0048	0.0101	0	0	0	0	0.0002

Table 24. **Testing of constant returns to scale for the OLS model with fixed-effects** *(cont.)*

NACE	Sector	HUN	IRL	ISL	ITA	NLD	NOR	POL	PRT	SVK	SWE
40	Electricity, gas, etc.	31.44	92 733.73	. .	12.49	0.28	6.01	41.93	19.53	7.59	28.66
		0	*0*	. .	*0.0004*	*0.5999*	*0.0142*	*0*	*0*	*0.0059*	*0*
41	Water collection,	680.14	. .	. .	4.49	5.04	3.96	152.59	21.9	0	27.79
	purification, etc.	*0*	. .	. .	*0.0341*	*0.0247*	*0.0465*	*0*	*0*	*0.9941*	*0*
45	Construction	31.63	3.67	2.56	1 547.32	6.52	280.44	244.39	22.88	50.4	80.97
		0	*0.0554*	*0.1094*	*0*	*0.0107*	*0*	*0*	*0*	*0*	*0*
50	Sale, maintenance, etc.	6.41	2.14	. .	227.98	0	177.33	214.08	21.58	13.49	168.88
		0.0113	*0.1436*	. .	*0*	*0.9541*	*0*	*0*	*0*	*0.0002*	*0*
51	Wholesale trade, etc.	0.09	8.7	3.63	946.06	6.69	234.33	1 467.44	34.5	170.28	412.06
		0.7662	*0.0032*	*0.0568*	*0*	*0.0097*	*0*	*0*	*0*	*0*	*0*
52	Retail trade	0.02	1.36	21.69	202.98	3.48	160.53	35.75	21.25	9.95	194.69
		0.8888	*0.2443*	*0*	*0*	*0.0622*	*0*	*0*	*0*	*0.0016*	*0*
55	Hotels and restaurants	8 965.65	1.13	0.07	152.01	10.68	77.01	108.77	6.24	1.58	27.71
		0	*0.2888*	*0.7956*	*0*	*0.0011*	*0*	*0*	*0.0125*	*0.2089*	*0*
60	Land transport	0.69	1.23	231.24	218.31	3.49	84.98	186.92	8.43	8.46	15
		0.4077	*0.2681*	*0*	*0*	*0.0617*	*0*	*0*	*0.0037*	*0.0036*	*0.0001*
61	Water transport	. .	0	. .	54.35	0.01	28.94	139.34	213.99	4.50E + 07	4.77
		. .	*0.9899*	. .	*0*	*0.9232*	*0*	*0*	*0*	*0*	*0.0289*
62	Air transport	. .	41 905.86	. .	12.07	2.65	15.08	8.21	90.59	848.35	1.89
		. .	*0*	. .	*0.0005*	*0.1034*	*0.0001*	*0.0042*	*0*	*0*	*0.1689*
63	Supporting, etc.	1.66	9.62	35 885.29	226.2	0.02	34.6	120.72	12.4	49.26	22.73
		0.1973	*0.0019*	*0*	*0*	*0.8967*	*0*	*0*	*0.0004*	*0*	*0*
641	Post and courier activ.	15 661.43	1.00E + 05	40 298.85	10.25	. .	59.34	0.05	40 638.24	2.40E + 06	0.33
		0	*0*	*0*	*0.0014*	. .	*0*	*0.8299*	*0*	*0*	*0.568*
642	Telecommunications	0.3	9.9	. .	8.46	5.73	4.86	8.36	1 033.34	128.09	0.79
		0.5827	*0.0017*	. .	*0.0036*	*0.0167*	*0.0274*	*0.0038*	*0*	*0*	*0.3739*
65		1.60E + 06	2.21	. .	19.87	1.59	0.54	7.14	. .	7.21	18.4
	Financial intermediation	*0*	*0.1375*	. .	*0*	*0.2078*	*0.4613*	*0.0075*	. .	*0.0073*	*0*
67	Activ. auxiliary	. .	0.56	1.30E + 06	6.18	. .	0.25	0.69	. .	1.45	7.85
	to fin. int.	. .	*0.4547*	*0*	*0.0129*	. .	*0.6156*	*0.4077*	. .	*0.2289*	*0.0051*
70	Real estate	1.54	3.40E + 05	2.04	287.63	9.44	309.32	40.64	1.17	14.39	101.3
		0.214	*0*	*0.1533*	*0*	*0.0021*	*0*	*0*	*0.2787*	*0.0001*	*0*
71	Renting	8 908.22	455.7	. .	20.73	2 336.59	15.98	3.42	7.90E + 06	11.26	10.13
		0	*0*	. .	*0*	*0*	*0.0001*	*0.0646*	*0*	*0.0008*	*0.0015*
72	Computer activities	2.03	0.34	33 624.95	347.18	1.21	32.83	28.41	3.25	77.63	8.27
		0.1547	*0.5587*	*0*	*0*	*0.2714*	*0*	*0*	*0.0712*	*0*	*0.004*
73	Research	1.80E + 06	36.6	. .	12.01	0.73	9.55	362.09	0.34	3.19	2.54
	and development	*0*	*0*	. .	*0.0005*	*0.3935*	*0.002*	*0*	*0.5592*	*0.0739*	*0.1108*
74	Other business activ.	4.69	9.43	. .	566.93	0.23	97.85	45.35	0.34	27.92	13.61
		0.0303	*0.0021*	. .	*0*	*0.6313*	*0*	*0*	*0.5579*	*0*	*0.0002*
7411	Legal activ.	. .	. .	. .	102.06	. .	2.71	19.33	. .	6 137.13	1.1
		. .	. .	. .	*0*	. .	*0.0995*	*0*	. .	*0*	*0.2946*
7412	Accounting, etc.	. .	. .	. .	49.39	. .	3.63	21.44	. .	0.63	10.69
		. .	. .	. .	*0*	. .	*0.0568*	*0*	. .	*0.4284*	*0.0011*
7413	Market research, etc.	. .	4 895.8	. .	46.93	. .	32.79	19.71	. .	3.42	1.38
		. .	*0*	. .	*0*	. .	*0*	*0*	. .	*0.0643*	*0.2407*
7414	Bus. and man.	9.00E + 06	13.42	. .	91.46	. .	12.01	15.34	100.39	41.46	21.54
	consultancy activ.	*0*	*0.0002*	. .	*0*	. .	*0.0005*	*0.0001*	*0*	*0*	*0*
7415	Man. activ. of holding	22.73	9.11	. .	5.28	28.84	0.18	3.91	0.22	. .	31.52
	companies	*0*	*0.0025*	. .	*0.0216*	*0*	*0.6736*	*0.0479*	*0.6422*	. .	*0*
7420	Architectural, etc.	66.06	19 582.46	1.09	269.94	0.1	25.44	44.48	2.7	62.42	5.84
		0	*0*	*0.2955*	*0*	*0.7473*	*0*	*0*	*0.1004*	*0*	*0.0156*
80	Education	. .	19 117.88	. .	113.64	. .	76.43	54.79	228.74	1.65	9.88
		. .	*0*	. .	*0*	. .	*0*	*0*	*0*	*0.1992*	*0.0017*
7599	Other	3.31	0.52	4.43	405.61	2.03	117.72	167.27	22.21	97.47	14.89
		0.0689	*0.4729*	*0.0353*	*0*	*0.1543*	*0*	*0*	*0*	*0*	*0.0001*

Note: Results of the *t*-test with *p*-values in italics.

Table 25. **Testing of constant returns to scale for the model with computed input coefficients**

NACE	Sector	AUT	BEL	CHE	CZE	DEU	DNK	ESP	FIN	FRA	GBR	GRC
40	Electricity, gas, etc.	–8.1873	–23.2193	–31.6721	–15.8109	–74.9048	2.6	–51.4132	–41.5209	–55.912	–11.6764	3.8719
		0	*0*	*0*	*0*	*0*	*0.0099*	*0*	*0*	*0*	*0*	*0.0002*
41	Water collection,	–3.3004	–18.8076		–3.3196	–32.8962	1.1073	–58.7568	–4.8285	–60.0935	–1.0309	2.5927
	purification, etc.	*0.1873*	*0*		*0.0011*	*0*	*0.2801*	*0*	*0*	*0*	*0.3046*	*0.0196*
45	Construction	–28.6319	–1.00E + 02	–6.8657	–1.40E + 02	–1.30E + 02	4.3923	–4.30E + 02	–1.90E + 02	–8.20E + 02	4.5158	–29.2294
		0	*0*	*0.0005*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
50	Sale, maintenance, etc.	–10.0634	–82.1891	–19.8861	–1.60E + 02	–57.4503	–14.6678	–2.60E + 02	–1.00E + 02	–3.80E + 02	–41.2769	–72.8214
		0	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
51	Wholesale trade, etc.	–37.7604	–1.90E + 02	–12.7008	–4.30E + 02	–96.981	–30.9247	–5.60E + 02	–2.10E + 02	–6.60E + 02	–1.80E + 02	–1.50E + 02
		0	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
52	Retail trade	–21.6279	–95.8345	–53.9187	–2.20E + 02	–69.1777	–38.4304	–3.00E + 02	–1.80E + 02	–5.40E + 02	–98.6144	–67.5741
		0	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
55	Hotels and restaurants	–16.3867	–62.7656	–20.3217	–32.7237	–37.075	–5.268	–2.90E + 02	–1.20E + 02	–4.20E + 02	–45.5322	–9.8969
		0	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
60	Land transport	–16.8373	–73.1832	–24.0469	–52.4652	–23.6787	4.2811	–2.30E + 02	–92.4458	–5.10E + 02	33.2215	–8.4974
		0	0	0	0	0	0	0	0	0	0	0
61	Water transport	–5.166	–11.2378	–1.5625	–2.9112	–10.4948	–6.4037	–33.6007	–27.6355	–61.2822	0.1334	–0.6169
		0.0141	*0*	*0.1789*	*0.0142*	*0*	*0*	*0*	*0*	*0*	*0.8939*	*0.5384*
62	Air transport	–2.5056	–8.9098	–6.698	–34.4839	–5.1196	–2.2564	–33.1704	–19.1161	–64.5192	1.3677	5.0747
		0.0664	*0*	*0*	*0*	*0.0001*	*0.0297*	*0*	*0*	*0*	*0.1718*	*0*
63	Supporting, etc.	–13.371	–46.1511	–10.0992	–53.9876	–41.178	–3.0021	–1.20E + 02	–51.394	–2.00E + 02	–24.8643	–22.841
		0	*0*	*0*	*0*	*0*	*0.0029*	*0*	*0*	*0*	*0*	*0*
641	Post and courier activ.	. .	–11.1916		–12.0163	–12.1735	–0.9359	–42.4135	–35.7809	–29.6851	–5.548	
		. .	*0*		*0*	*0*	*0.3565*	*0*	*0*	*0*	*0*	
642	Telecommunications	–5.0261	–12.42		–17.6567	–15.5455	–1.706	–33.2882	–29.2522	–43.939	–10.1979	
		0.0374	*0*		*0*	*0*	*0.0908*	*0*	*0*	*0*	*0*	
65	Financial	–1.2798	–25.0771	. .	–9.3719	–9.1519	–7.6579	–13.4118	–27.3147	–34.5582	–30.1394	–3.432
	intermediation	*0.4222*	*0*	.	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0.0007*
67	Activ. auxiliary	–6.9462	–16.432		–12.8769	–7.7954	–3.6851	–38.156	–17.2314	–47.5938	–14.8033	–20.408
	to fin. int.	*0*	*0*		*0*	*0*	*0.0005*	*0*	*0*	*0*	*0*	*0*
70	Real estate	–4.7135	–51.1592	–2.2758	–26.738	–25.999	–9.5568	–2.10E + 02	–74.532	–1.80E + 02	–51.9703	–6.7365
		0.0001	*0*	*0.1506*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
71	Renting	–7.7603	–30.6603		–19.4072	–22.0104	1.4908	–1.30E + 02	–31.4842	–1.80E + 02	5.4519	4.4546
		0.0001	*0*		*0*	*0*	*0.1382*	*0*	*0*	*0*	*0*	*0*
72	Computer activities	–11.7735	–53.521	–11.2922	–66.811	–50.097	–4.6176	–1.00E + 02	–75.8421	–2.20E + 02	–30.8365	–9.6073
		0	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
73	Research	–7.7936	–12.3206		–17.1295	–15.7769	–0.0687	–27.181	–17.437	–50.5051	5.459	
	and development	*0*	*0*		*0*	*0*	*0.9455*	*0*	*0*	*0*	*0*	
74	Other business activ.	–6.9134	–58.8612	–6.8412	–57.2315	–47.1804	–1.5682	–1.70E + 02	–1.00E + 02	–2.80E + 02	–17.5791	–22.4986
		0	*0*	*0*	*0*	*0*	*0.1174*	*0*	*0*	*0*	*0*	*0*
7411	Legal activ.		–17.3771		–10.7005		–5.8282	–36.0771	–27.9322	–36.8508	–2.4387	–8.1989
			0		*0*		*0*	*0*	*0*	*0*	*0.0168*	*0.0001*
7412	Accounting, etc.	. .	–17.2628		–26.8046	–7.6389	0.8078	–60.3572	–50.6247	–1.40E + 02	1.5777	–8.07
		. .	*0*		*0*	*0*	*0.4233*	*0*	*0*	*0*	*0.1177*	*0*
7313	Market research, etc.		–15.3407	–6.7792	–19.4617	–6.8158	–1.2827	–36.9396	–31.2464	–38.4452	–16.636	–10.1474
			0	*0.0066*	*0*	*0*	*0.2083*	*0*	*0*	*0*	*0*	*0*
7414	Bus. and man.	. .	–29.5571	–1.5457	–23.4669	–25.6781	–1.0071	–51.6026	–43.5727	–89.9395	–4.6786	–24.0575
	consultancy activ.	. .	*0*	*0.3656*	*0*	*0*	*0.3155*	*0*	*0*	*0*	*0*	*0*
7415	Man. activ. of holding	–13.8775	–37.2418	–45.6281	–9.0024	–69.8983	–5.5126	–37.5404	–7.331	–1.40E + 02	–6.7304	–7.1738
	companies	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
7420	Architectural, etc.	–7.8122	–34.5353		–61.4379	–41.619	–1.1764	–1.10E + 02	–98.6471	–1.90E + 02	7.1098	–17.0477
		0	*0*		*0*	*0*	*0.2401*	*0*	*0*	*0*	*0*	*0*
80	Education	. .	–16.5693	–19.7447	–11.0999	–17.5008	–3.8887	–1.10E + 02	–47.7325	–1.20E + 02	6.5537	13.239
		. .	*0*	*0.0026*	*0*	*0*	*0.0003*	*0*	*0*	*0*	*0*	*0*
7599	Other	–5.1039	–68.4634	–15.1135	–49.9947	–50.4705	–1.2749	–2.10E + 02	–93.209	–4.80E + 02	–12.296	5.4554
		0	*0*	*0*	*0*	*0*	*0.2028*	*0*	*0*	*0*	*0*	*0*

Table 25. **Testing of constant returns to scale for the model with computed input coefficients** *(cont.)*

NACE	Sector	HUN	IRL	ISL	ITA	NLD	NOR	POL	PRT	SVK	SWE
40	Electricity, gas, etc.	–12.5133		–8.2684	–59.4006	–13.7294	–44.3084	–36.4522	–22.7129	–13.7133	–57.9184
		0		*0.0766*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
41	Water collection, purification, etc.	–6.7876			–63.3987	–35.7552	–11.2777	–17.1172	–16.1657	–9.1075	–17.9949
		0			*0*	*0*	*0*	*0*	*0*	*0*	*0*
45	Construction	–47.2275	. .	–23.5411	–5.60E + 02	–37.0385	–2.80E + 02	–1.40E + 02	–1.80E + 02	–49.3503	–2.60E + 02
		0	. .	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
50	Sale, maintenance, etc.	–43.8018		–6.1251	–2.00E + 02	–4.2652	–2.00E + 02	–35.8338	–1.20E + 02	–40.0787	–1.10E + 02
		0		*0*	*0*	*0.0001*	*0*	*0*	*0*	*0*	*0*
51	Wholesale trade, etc.	–82.1291		–11.1754	–4.80E + 02	–32.44	–3.00E + 02	–94.8462	–1.40E + 02	–87.1986	–2.50E + 02
		0		*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
52	Retail trade	–39.3762		–12.4036	–2.50E + 02	–12.648	–3.30E + 02	–46.6385	–90.8423	–73.2475	–2.20E + 02
		0		*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
55	Hotels and restaurants	–9.7569		–13.83	–2.10E + 02	–19.1077	–2.30E + 02	–28.0725	–40.7558	–11.7553	–2.10E + 02
		0		*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
60	Land transport	–35.1237		–7.2616	–2.40E + 02	–16.1965	–1.20E + 02	–56.1779	–27.3772	–24.1269	–1.10E + 02
		0		0	0	0	0	0	0	0	0
61	Water transport	–4.2206		–45.602	–57.4034	–5.5828	–38.347	–14.0262	–10.9891	. .	–25.9197
		0.0009		*0*	*0*	*0.0003*	*0*	*0*	*0*	. .	*0*
62	Air transport	–4.5352		. .	–48.7984	–21.3628	–10.2749	–14.6325	–25.9362	–7.5826	–8.5002
		0.0005		. .	*0*	*0*	*0*	*0*	*0*	*0.0016*	*0*
63	Supporting, etc.	–16.472		–6.5297	–2.10E + 02	–18.4289	–49.7942	–59.2815	–7.3105	–32.8637	–41.687
		0		*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
641	Post and courier activ.	–5.1023		–7.2338	–26.3231		–16.5517	–13.3717	–5.1395	–11.6519	–13.7059
		0.0001		*0.0008*	*0*		*0*	*0*	*0.0143*	*0.0073*	*0*
642	Telecommunications	–8.2944		0.5806	–29.5199	–18.9616	–18.7791	–24.4605	–19.1418	–9.2081	–20.5048
		0		*0.5867*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
65	Financial intermediation	–3.5001		–4.1555	–44.1915	–6.1741	–31.3894	–32.738		–9.4342	–40.2452
		0.0035		*0.0043*	*0*	*0*	*0*	*0*		*0*	*0*
67	Activ. auxiliary to fin. int.	–8.8598		–13.5085	–83.9389		–13.6612	–25.5564		–17.6063	–33.1883
		0		*0*	*0*		*0*	*0*		*0*	*0*
70	Real estate	–26.1343		–6.176	–1.40E + 02	–7.2504	–1.10E + 02	–28.8471	–33.7189	–25.9877	–1.20E + 02
		0		*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
71	Renting	–12.7062		–1.106	–72.8088	–8.7453	–61.208	–18.9603	–13.1764	–21.8911	–78.4173
		0		*0.3111*	*0*	*0.0009*	*0*	*0*	*0*	*0*	*0*
72	Computer activities	–23.659		–3.6229	–2.10E + 02	–19.8309	–86.5057	–50.7834	–19.3324	–22.6141	–94.933
		0		*0.0008*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
73	Research and development	–6.1775			–57.7423	–14.0823	–14.1396	–38.2476	–13.352	–12.3861	–23.3963
		0			*0*	*0*	*0*	*0*	*0*	*0*	*0*
74	Other business activ.	–16.8849		–3.7912	–1.90E + 02	–14.7758	–1.00E + 02	–50.1837	–24.037	–24.0469	–1.50E + 02
		0		*0.0068*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
7411	Legal activ.	–2.084			–33.6532		–5.3684	–53.892		. .	–12.464
		0.2848			*0*		*0.001*	*0*		. .	*0*
7412	Accounting, etc.	–5.1705		–10.2432	–60.1633		–69.3897	–27.0167	–5.7398	–15.604	–36.0041
		0.0001		*0.002*	*0*		*0*	*0*	*0.0046*	*0*	*0*
7313	Market research, etc.	–4.2698			–68.8925		–19.9877	–21.4278		–14.668	–10.9321
		0.0053			*0*		*0*	*0*		*0*	*0*
7414	Bus. and man. consultancy activ.	–6.1822		–4.1079	–1.10E + 02	. .	–34.8911	–26.4118	–11.4249	–19.4708	–87.4392
		0		*0.0261*	*0*	. .	*0*	*0*	*0*	*0*	*0*
7415	Man. activ. of holding companies	–3.8851	–5.7966	–2.4907	–57.1783	–10.9187	–8.951	–7.1932	–41.6911		–1.10E + 02
		0.0002	*0.0102*	*0.0178*	*0*	*0*	*0*	*0*	*0*		*0*
7420	Architectural, etc.	–17.847		–12.131	–1.30E + 02	–13.4034	–87.7345	–57.8939	–30.5133	–27.4112	–95.8254
		0		*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
80	Education	–4.7615		–2.5976	–82.8172		–58.635	–55.9805	–5.9867	–4.6975	–87.3345
		0.0005		*0.1217*	*0*		*0*	*0*	*0*	*0.0003*	*0*
7599	Other	–16.4205		–13.5527	–2.70E + 02	–23.3415	–1.60E + 02	–62.7641	–37.1201	–21.0768	–1.60E + 02
		0		*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*

Note: Results of the *t*-test with *p*-values in italics.

Notes

1. Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Korea, Luxembourg, Netherlands, Norway, Spain, Sweden, the United Kingdom and the United States.
2. Electricity, gas and water supply; wholesale and retail trade, repairs; transport and storage; post and telecommunications, financial intermediation and business services.
3. Due to the limited availability of data, Høj *et al.* (2007) estimate mark-ups for all the six services sectors for eight countries only: Austria, Germany, Denmark, Finland, France, Netherlands, Norway and the United States. No services mark-ups are available from the study for Spain, and the number of service sectors for which mark-ups are estimated varies between one and five for the remaining countries. Owing to insufficient length of time series, mark-ups are not estimated for any Central European country.
4. Christopoulou and Vermeulen estimate mark-ups for 27 service industries, including electricity and gas; water supply; construction; sale, maintenance and retail of motor vehicles and motorcycles and retail sale of fuel; wholesale trade; retail trade; hotels and restaurants; inland transport; water transport; air transport; other supporting and auxiliary transport; post and telecommunications; financial intermediation; insurance and pension funds; activities related to financial intermediation; real estate; renting; computer and related activities; research and development; other business activities; public administration, defence and compulsory social security; education; health and social work; sewage and refuse disposal, sanitation and similar activities; activities of membership organisations; recreational, cultural and sporting activities and other service activities, and nine countries, including Austria, Belgium, Finland, France, Germany, Italy, Netherlands, Spain and the United States for the period of 1981-2004 and two sub-periods of 1981-92 and 1993-2004.
5. Bouis and Klein (2009) estimate mark-ups for nine service industries including electricity, gas and water; construction; sale, maintenance and retails of motor vehicles and motorcycles and retail sale of fuel; wholesale trade; retail trade; hotels and restaurants; transport; post and telecommunications and renting for 11 countries including Austria, Belgium, Denmark, Finland, France, Italy, Japan, Netherlands, Spain, United Kingdom and the United States.
6. Through differentiation, the growth rate of output can be related to the growth rates of inputs, *i.e.* capital, labour and materials.
7. Unlike the case of sectoral data, adjustment for differences in tax systems across countries is not necessary as no taxes affect only one side of either inputs or outputs.
8. For Hungary, data for the yield on benchmark government ten-year bonds were obtained from the National Bank of Hungary and for Greece from Eurostat. Given the lack of such data for the Czech Republic and Poland, long-term lending rates are used.
9. Except insurance and pension funds, which are missing from the data base.
10. For Ireland, no estimates were obtained owing to a small number of observations.
11. Superior techniques such as the Levinsohn-Petrin method could also be employed to estimate the input coefficients of the production function. In that case, however, the estimation would need to proceed by sector and country, as the estimation procedure does not allow for estimating country- and sector-specific coefficients for pooled data.
12. It is interesting to note that the measurement error for the real estate industry, which is highly capital intensive, appears much larger for industry-level estimation, as the sizes of estimated mark-ups for this sector show in Christopoulou and Vermeulen (2008). This may be related to the inclusion of owner-occupied housing in industry-level data, which is highly susceptible to measurement error.

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ANNEX A1

Derivation of Primal and Dual Solow Residuals

The primal Solow residual

The production technology is assumed to be defined by the neoclassical production function:

$$Y = AF(N,M,K) \tag{A1.1}$$

where Y is output and A is multifactor productivity growth. There are three inputs: N is labour, M is intermediate inputs and K is capital, and $F(.)$ is a homogenous function of degree lambda (the degree of returns to scale). The firm and year subscripts are subsumed for the sake of simplicity. After log-differentiation:*

$$y = \varepsilon_N n + \varepsilon_M m + \varepsilon_K k + a \tag{A1.2}$$

where the lower case indicates log differentiation and ε_i ($i = N, M, K$) is the elasticity of output with respect to input i equalling factor i's share of total cost (in the case of perfect competition). For labour, for instance,

$$\varepsilon_N = \frac{WN}{C_m Y} \tag{A1.3}$$

where W is the price of labour and C_m is marginal cost. Labour's share of total revenue, in turn is:

$$\alpha_N = \frac{WN}{PY} \tag{A1.4}$$

where P is the price of output. Under perfect competition, price equals marginal cost and hence equations A1.3 and A1.4 are identical. Imperfect competition, in contrast, implies that firms charge a mark-upμ over marginal cost:

$$\mu = \frac{P}{C_m} \tag{A1.5}$$

and thus

$$\varepsilon_N = \mu\alpha_N \tag{A1.6}$$

Cost and revenue shares for materials and capital can be derived similarly to those for labour. In the case of constant returns to scale:

$$\Sigma_{i=N,M,K}\varepsilon_i = 1 \tag{A1.7}$$

* Through differentiation, the growth rate of output can be related to the growth rates of inputs, *i.e.* capital, labour and materials.

Substituting A1.7 and A1.6, adding y and subtracting k from both sides of equation A1.2 and rearranging results in the primal Solow residual:

$$SR_{primal} = y - \alpha_N n - \alpha_M m - \alpha_K k = (1 - B)a - B(y - k) \quad \text{(A1.8)}$$

where B is the Lerner index closely related to the mark-up μ:

$$B = 1 - \frac{1}{\mu} \quad \text{(A1.9)}$$

The dual Solow residual

The cost function corresponding to the production function in A1.1 is (subscripts subsumed):

$$C(W, P_M, R, Y, A) = \frac{G(W, P_M, R)Y}{A} \quad \text{(A1.10)}$$

while the marginal cost function is

$$Q = \frac{G(W, P_M, R)}{A} \quad \text{(A1.11)}$$

Log-differentiation of (A1.11), making use of Shephard's lemma gives

$$q = \varepsilon_N w + \varepsilon_M p_M + \varepsilon_K r + a \quad \text{(A1.12)}$$

Constant mark-ups imply

$$p = q \quad \text{(A1.13)}$$

Using A1.13, A1.6 and A1.7 to substitute into A1.12, adding r and subtracting p from both sides and rearranging gives the dual Solow residual

$$SR_{dual} = \alpha_N w + \alpha_M p_m + \alpha_K r - p = (1 - B)a - B(p - r) \quad \text{(A1.14)}$$

ANNEX A2

Data Sources and Description of the Sample

The Amadeus data base used for the analyses contains nearly 1.5 million firms and observations for 14 years, but given the unbalanced nature of the data and missing observations for some variables, only a subset was suitable for the estimation of mark-ups. To improve the quality of the data, several filtering rules were applied. At the first stage, when the input coefficients were estimated for the production function, nearly 2.4 million observations were retained after deleting the observations where some of the data necessary for the estimation were missing (sales/operating revenues, labour, materials and fixed assets). The distribution of these observations across countries and sectors is very uneven: some countries like France and Spain have over half a million observations, while Iceland has only a few hundred (Table A2.1). Likewise, some sectors, such as wholesale trade, have over 600 000 observations, while legal services only 1 500.

At the second stage, only those observations were retained for which the estimated input coefficients were of a plausible size, *i.e.* each was in the range of [0, 1] and if they were significant. This way 2.3 million observations were retained (Table A2.2).

Table A2.1. **Number of observations at the first stage of estimation**

NACE 2		AUT	BEL	CHE	CZE	DEU	DNK	ESP	FIN	FRA	GBR	GRC	HUN	IRL	ISL	ITA	NLD	NOR	POL	PRT	SWE	SVK	**Total**
40	Electricity, gas, etc.	26	234	502	503	1 636	312	1 775	1 351	808	919	157	38	7	1	2 234	78	1 213	1 843	90	1 695	67	**15 489**
41	Water collection, purification, etc.	3	165	0	204	205	32	1 337	214	612	161	28	17	1		961	33	26	1 136	37	41	20	**5 233**
45	Construction	163	6 286	10	4 189	960	3 038	100 365	12 086	91 250	24 534	5 661	266	195	100	68 676	853	28 626	5 677	1 791	25 074	641	**380 441**
50	Sale, maintenance, etc.	89	4 533	10	1 854	398	1 643	41 738	5 559	51 406	15 147	5 824	206	94	6	36 207	62	18 755	2 637	178	18 611	229	**205 186**
51	Wholesale trade, etc.	445	26 757	114	8 629	2 494	5 163	159 459	17 032	149 051	40 784	27 821	792	360	35	137 465	713	35 760	12 332	974	45 951	1 215	**673 346**
52	Retail trade	92	4 655	119	3 082	722	2 649	43 507	8 486	88 154	12 167	3 465	273	149	38	44 091	33	32 720	2 975	144	24 365	1 000	**272 886**
55	Hotels and restaurants	24	1 014	70	788	129	567	26 336	3 000	25 243	10 476	9 103	19	48	30	11 862	69	8 810	572	264	7 240	110	**105 774**
60	Land transport	58	2 769	161	1 011	529	620	20 928	3 807	25 428	5 762	849	126	55	8	16 221	54	3 838	2 133	131	5 306	180	**89 974**
61	Water transport	3	132	7	16	56	191	750	306	424	1 428	224	1	19	0	1 090	13	521	32	16	329	3	**5 561**
62	Air transport	4	46	11	9	22	55	302	77	304	940	69	0	9	0	356	21	56	20	12	85	6	**2 404**
63	Supporting, etc.	39	2 354	9	608	419	530	13 722	2 318	8 482	6 326	3 234	75	31	10	16 274	49	3 033	1 187	56	2 607	121	**61 484**
65	Financial intermediation	3	627	2	192	44	1 343	240	744	946	3 937	361	2	24	3	1 287	54	245	584	0	1 072	48	**11 758**
67	Activ. auxiliary to fin. int.	17	206	0	120	10	86	970	324	1 142	887	1 055	3	25	5	961	0	79	279	0	1 016	51	**7 236**
70	Real estate	26	1 790	5	1 543	515	1 543	41 389	2 283	14 658	10 739	884	94	8	15	11 154	54	6 262	3 671	150	8 437	390	**105 610**
71	Renting	14	630	0	169	128	205	4 595	417	5 156	2 235	338	10	21	0	1 932	6	1 161	115	3	2 063	106	**19 304**
72	Computer activities	35	1 833	36	952	577	1 080	6 531	2 484	12 090	13 335	822	61	169	8	12 183	77	3 879	937	28	4 517	123	**61 757**
73	Research and development	16	113	0	119	171	119	580	236	1 015	1 267		4	12	1	1 161	13	204	709	8	566	93	**6 407**
74	Other business activ.	39	2 723	27	1 639	771	913	23 131	3 130	21 257	23 137	1 583	62	122	1	17 257	91	5 475	1 090	91	6 641	315	**109 495**
80	Education	1	80	4	173	59	69	3 988	386	1 506	1 332	797	3	4	0	1 350	0	540	691	8	1 095	22	**12 108**
641	Post and courier activ.	2	75	0	37	41	49	715	242	138	287	114	5	2	4	130	0	103	30	2	38	6	**2 020**
642	Telecommunications	5	378	0	152	59	166	1 794	556	815	2 590	194	17	41	0	760	34	647	324	18	285	20	**8 855**
7411	Legal activ.	0	58	0	14	0	31	391	221	232	132	11	0	0	0	156	0	15	69	0	195	2	**1 527**
7412	Accounting, etc.	0	125	0	251	7	88	1 914	384	2 081	170	160	6	0	0	1 269	0	712	165	0	735	43	**8 110**
7413	Market research, etc.	0	150	5	64	11	56	610	130	414	759	269	1	5	0	1 645	0	116	68	0	113	36	**4 452**
7414	Bus. and man. consultancy activ.	0	547	3	325	150	298	1 746	901	2 639	2 970	1 279	9	18	1	5 089	2	754	475	20	3 891	134	**21 251**
7415	Man. activ. of holding companies	126	1 148	1 192	60	2 224	3 799	1 560	106	10 018	6 367	274	19	60	5	2 233	9	21	102	361	5 734		**35 418**
7420	Architectural, etc.	16	983	2	1 033	305	649	6 116	2 578	8 424	1 562	521	35	6	16	4 646	126	3 637	882	43	4 004	238	**35 822**
7599	Other	60	2 563	202	1 653	1 691	970	22 677	3 640	30 232	20 310	2 139	52	109	28	21 727	128	7 117	3 022	178	5 953	234	**124 685**
Total		**1 306**	**62 974**	**2 491**	**29 389**	**14 333**	**26 264**	**529 166**	**72 998**	**553 925**	**210 660**	**67 236**	**2 196**	**1 594**	**315**	**420 377**	**2 572**	**164 325**	**43 757**	**4 603**	**177 659**	**5 453**	**2 393 593**

Note: The number of firm-year observations where all the necessary variables for the estimation of the production functions were available.

Table A2.2. **Number of observations at the second stage of estimation**

NACE 2	Sector	AUT	BEL	CHE	CZE	DEU	DNK	ESP	FIN	FRA	GBR	GRC	HUN	IRL	ISL	ITA	NLD	NOR	POL	PRT	SWE	SVK	**Total**
40	Electricity, gas, etc.	28	215	461	354	1 983	258	1 764	1 500	782	647	86	198	0	2	1 650	73	957	1 302	196	1 403	67	**13 926**
41	Water collection, purification, etc.	2	152	0	167	280	23	1 335	250	545	124	17	96	0		804	35	20	868	93	32	20	**4 863**
45	Construction	217	5 330	7	2 692	3 838	2 172	100 924	12 750	111 734	19 811	2 967	2 442	1	349	65 908	724	24 845	4 192	4 910	20 163	487	**386 463**
50	Sale, maintenance, etc.	101	3 834	9	1 247	1 408	1 193	44 294	5 687	60 963	12 553	3 091	1 698	0	50	34 490	49	16 245	2 128	727	15 358	187	**205 312**
51	Wholesale trade, etc.	523	22 779	102	5 474	5 910	3 585	171 548	17 658	171 686	33 264	14 421	5 829	0	179	129 009	613	30 955	9 888	2 908	37 526	986	**664 843**
52	Retail trade	115	3 830	112	1 908	1 883	1 988	47 249	8 800	104 500	10 021	1 743	1 779	0	185	44 376	27	28 165	2 194	660	19 674	866	**280 075**
55	Hotels and restaurants	22	856	74	497	270	400	27 116	3 042	31 343	8 532	5 093	156	0	102	11 850	57	7 515	446	972	5 758	82	**104 183**
60	Land transport	101	2 264	175	642	859	412	22 541	3 954	28 465	4 679	377	961	0	39	15 522	47	3 125	1 633	381	3 542	153	**89 872**
61	Water transport	4	116	6	12	69	150	689	324	456	1 107	129	15	0	5	919	11	454	26	36	204	1	**4 733**
62	Air transport	5	37	18	6	20	40	268	78	285	767	36	15	0	1	319	19	41	17	21	50	5	**2 048**
63	Supporting, etc.	42	1 910	8	351	722	365	14 310	2 319	8 492	5 071	1 589	542	0	39	14 987	37	2 393	918	80	1 612	102	**55 889**
65	Financial intermediation	2	534	1	139	52	821	215	727	1 099	2 796	225	17	0	9	980	25	478	520	0	712	30	**9 382**
67	Activ. auxiliary to fin. int.	13	157	0	72	22	59	877	299	1 232	581	618	38	0	7	925	0	59	248	0	607	35	**5 849**
70	Real estate	32	1 501	3	989	1 025	892	37 262	2 399	15 798	6 478	493	809	0	47	8 862	36	6 665	2 936	546	5 493	345	**92 611**
71	Renting	9	532	0	109	243	148	4 757	407	5 464	1 815	175	105	0	7	1 809	5	1 087	95	35	1 609	106	**18 517**
72	Computer activities	36	1 386	30	558	985	709	6 290	2 281	12 307	9 933	416	365	0	45	10 967	58	3 034	714	80	3 184	104	**53 482**
73	Research and development	19	86	0	78	241	77	570	221	1 023	988		48	0	0	1 025	10	147	542	13	387	69	**5 544**
74	Other business activ.	41	2 221	25	972	1 102	615	22 471	3 189	24 081	17 205	787	420	0	8	15 632	74	4 416	827	262	4 774	223	**99 345**
80	Education	1	56	3	80	142	45	4 156	411	1 803	1 021	436	13	0	3	1 202	0	436	817	23	739	16	**11 403**
641	Post and courier activ.	1	62	0	25	46	32	706	261	143	229	0	16	0	6	142	0	70	21	4	23	3	**1 790**
642	Telecommunications	3	297	0	107	71	113	1 629	499	714	1 880	0	120	0	6	600	29	531	279	31	186	13	**7 108**
7411	Legal activ.	0	47	0	9	0	16	365	218	247	86	8	2	0	0	145	0	8	57	0	82	1	**1 291**
7412	Accounting, etc.	1	98	0	135	19	48	1 800	367	2 221	105	61	17	0	4	1 120	0	555	158	5	518	38	**7 270**
7413	Market research, etc.	0	108	4	34	16	36	607	126	391	598	156	7	0	0	1 427	0	94	58	0	67	40	**3 769**
7414	Bus. and man. consultancy activ.	1	417	2	193	277	168	1 609	880	2 650	2 225	654	78	0	4	4 328	1	560	408	44	2 608	117	**17 224**
7415	Man. activ. of holding companies	112	938	1 043	48	1 973	2 683	1 322	102	10 719	4 248	158	94	4	39	1 697	13	33	75	405	4 282		**29 988**
7420	Architectural, etc.	33	794	0	651	635	431	6 118	2 530	8 719	1 199	248	296	0	39	4 320	98	2 909	648	135	2 803	186	**32 792**
7599	Other	70	2 112	144	1 086	2 596	698	22 428	3 726	34 194	15 701	1 130	411	0	56	19 970	103	6 024	2 764	531	4 366	172	**118 282**
Total		**1 534**	**52 669**	**2 227**	**18 635**	**26 687**	**18 177**	**545 220**	**75 005**	**642 056**	**163 664**	**35 114**	**16 587**	**5**	**1 231**	**394 985**	**2 144**	**141 821**	**34 779**	**13 098**	**137 762**	**4 454**	**2 327 854**

Note: The number of firm-year observations where all the input coefficients were in the range of [0, 1] and significant.

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Structural Indicators: A Critical Review

by
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This article reviews and assesses, in terms of availability, reliability and transparency, existing policy and outcome indicators that have been found to be linked both directly and indirectly to economic growth and living standards. Indicators aiming at capturing the political and social situation of countries, as well as governance-related issues, are examined (e.g., *political system, political stability, corruption, crime and violence). Topics also include product and labour markets, infrastructure, trade, financial indicators and composite indices of reform.*

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Differences in living standards (generally proxied by income) across OECD countries reflect both different structural policy settings and institutional characteristics. Although there is a broad consensus that institutions and policy matter for living standards, these are not always easily captured through reliable and timely structural indicators. In recent years, a large number of indicators have been developed to fill this gap.

The last three decades have witnessed an intensive effort, both in the production of policy and outcome indicators and in linking these indicators to economic growth and living standards. This work has contributed to developing a better understanding of growth-enhancing policies, but has sometimes relied on the misuse of indicators. For this reason, it is useful to undertake an evaluation of these indicators and their potential use in empirical work, relating them to growth and living standards.

Following on and expanding the work by Loayza and Soto (2003), this paper reviews and assesses, in terms of availability, reliability and transparency, existing *policy* and *outcome indicators* that have been used and found to be linked, both directly and indirectly, to economic growth and living standards.

In more detail, the focus of the paper is on indicators produced by international organisations (including the OECD), think tanks and researchers. Special attention is given to indicators that are widely used in the literature. Coverage of the indicators discussed in the paper is not intended to be comprehensive, but rather selective in a number of important areas. Topics examined include product and labour markets, infrastructure, trade, financial indicators and composite indices of reform. Moreover, indicators aiming at capturing the political and social situation of countries, as well as governance-related issues, are assessed *(e.g.,* political system, political stability, corruption, crime and violence).

The rest of the paper is organised in two main sections: the first presents a typology of indicators that will be used throughout the paper, and the second reviews existing policy and outcome indicators. A detailed annex documenting the main features of these indicators can be found in Furceri and Mourougane (2009).

1. Typology of indicators

A wide range of indicators is currently produced by international organisations as well as individual researchers. They differ not only on their time and geographical coverage, but also by their intrinsic nature. Structural indicators can be differentiated according to a number of criteria, which are discussed in turn below.

1.1. Perception-based versus fact-based

Perception-based indicators rely on subjective assessments, usually drawn from surveys. Typical examples are corruption indices. By contrast, fact-based indicators usually rely on "hard" data derived from the legislation or institutional settings. Examples include

the Product Market Regulation (PMR) indicators or indices of Employment Protection Legislation (EPL).

The distinction between perception-based and fact-based indicators is important, not least because fact-based indicators are replicable (Table 1). Yet fact-based does not mean objective, as these indicators also embody a significant degree of subjectivity *(e.g.,* in the choice of questions). Moreover, assessments of complicated rules are subject to errors of fact and judgement, particularly when the analyst has to determine the net effect of conflicting rules and regulations. Perception-based and fact-based indicators are complementary sources of information. Perception-based information can be internal (results based upon the views of respondents from within the country) or external (results based upon assessments made by non-residents of the country).

Table 1. **Fact- and perception-based measures**

	Fact-based measures	Perception-based measures
Advantages	Do not rely on personal judgement Can be subject to peer review Exogenous to economic developments occurring at the time the data are collected Free of noise (other than measurement errors) Ownership more distinguishable	Easier to assemble a data base Answers reflect, in part, the way regulations are enforced Can cover all levels of regulation
Drawbacks	Require assembling a huge data base and assistance from governments and lawyers Often focus only on regulation at the national level (problem in federal countries where regulation can be carried out by local governments) Such measures cannot indicate certain ground-level features (how regulations are enforced) The quantification of regulations requires the construction and combination of various types of indexes, raising the questions of how to code the laws and how to weight them (entry point for subjectivity)	Rely on personal judgements Issue of comparability of answers between nations (most surveys ask questions that are specific to the country) No control on the type of questions asked Context specific

Source: Based on Nicoletti and Pryor (2006).

1.2. Single versus composite indicator

A composite indicator combines different sub-indicators into a single measure. Composite indicators have a number of advantages over single indicators. For example, if the same concept is measured by different data sources, it is possible to increase the coverage and reliability by combining the sources. A widely cited example is the *Governance Matters Reports* from the World Bank, which draw together 25 data sources into six composite indicators. The main weakness of composite indicators is that they are not always well constructed or used. In particular, one of the main downsides of composite indicators is that unless the component data are shown, it is not clear how the rating is derived. Such a lack of clarity weakens the basis for inferring policy prescriptions. In addition, all the existing composite indicators fail to capture the necessity to ensure coherence among various economic policies. In most cases, the composite indicator is simply the aggregation of unrelated sub-indicators, and the existing interactions between these variables are ignored (Table 2). A notable exception is the summary measure of tertiary education set-up developed by Oliveira Martins *et al.* (2007).

The unit chosen of the component indicator and the conversion of the underlying information into a scale that can be aggregated are non-trivial and can sometimes be

Table 2. **Pros and cons of composite indicators**

Advantages	Reduces multicollinearity
	Can summarise complex or multidimensional issues
	Easier to interpret than trying to find a trend in many separate indicators
	Facilitates the task of ranking countries
	Can assess progress of countries over time on complex issues
	Reduces the size of a set of indicators or includes more information
	Places issues of country performance and progress at the centre of the policy arena
	Facilitates communication with the general public and promotes accountability
Drawbacks	May send misleading policy messages if they are poorly constructed or misinterpreted
	May invite simplistic policy conclusions
	May be misused if the construction is not transparent and lacks sound statistical or conceptual principles
	The selection of indicators and weights could be the target of political challenge
	May disguise serious failing in some dimensions of policy and increase the difficulty of identifying proper remedial action
	May lead to inappropriate policies if dimensions of performance that are difficult to measure are ignored

Source: OECD, "Handbook on Constructing Composite Indicators: Methodology and User Guide", OECD Statistics Working Paper 2005/3.

questioned. The choice of the weights is also not straightforward. Weights can be derived either from theory or empirical analysis, usually principal component analysis. Alternatively, equal weights could be applied. Although the first alternative is more attractive from an analytical point of view, it is not without drawbacks. Indeed, some indicators have weights varying over time and, as a result, the ranking between countries can reflect more a change in weights than a change in policy. Robustness tests run in the context of the re-estimation of OECD product market regulations suggest that it is preferable to use equal weights in the multilateral surveillance process (Woefl *et al*., 2009).

Given the complexity of composite indicators, a number of characteristics have been identified to help users and to avoid misinterpretation. These relate to relevance, accuracy, timeliness, accessibility, interpretability and coherence (OECD, 2005).

1.3. Policy versus outcome measures

Policy indicators are instruments on which policy makers can have a direct impact (for instance, tax rates). However, these measures are often an imperfect proxy of the policy lever. Outcome measures capture the country performance in a specific domain and reflect the effects of national policy measures or institutional settings and the international environment. The indicator can be an intermediate, or a final, indicator of economic performance, for instance, the unemployment or employment rates. In general, reliable and timely measures are available, but policy makers can influence only indirectly such indicators via policy action.

2. Review of existing structural indicators

This section reviews the main policy and outcome indicators currently produced by international and other organisations. Indicators are discussed by policy topics (see the annex in Furceri and Mourougane, 2009, for a detailed and extensive description of the existing indicators by category).

2.1. Governance

The focus on governance has gained prominence over the last decade, following the move toward more open markets and less direct governmental control of business activities. Governance can be broadly defined as a system of values, processes, policies and

institutions by which a society manages its economic, political and social affairs. However, governance indicators are usually narrowed down to measure specific areas of governance, for instance, electoral systems, corruption, human rights, public service provision, civil society and gender equality.

Measuring governance is difficult, as this involves many institutions and players. Formal rules can be easily observed, but informal rules are non-observable, although they may have a greater influence on the quality of governance and require a deep understanding of society. Moreover, because the concepts are so broad, the same terms may be used in different ways.

Despite these difficulties, a large number of indicators have been constructed in recent years and cover both developed and developing economies. Among the hundreds of indicators that have emerged, the most widely used are policy, composite and perception-based indicators.

2.1.1. Institutional factors

The first strand of governance indicators aims to measure some aspects of good governance through institutional factors. By shaping the economic environment and influencing the behaviour of economic agents, formal and informal institutions have an impact on long-term growth. They are also associated with good development outcomes, in particular poverty reduction. The World Bank Governance Matters indicators have been pioneers in this area. They are based on expert assessments and surveys of firms and are updated every year. They cover different areas of governance, ranging from citizens' freedom to political stability and regulatory effectiveness. These indicators are constructed in such a way that their average across all countries is always zero and the standard deviation is always one. As a result, their scale is arbitrary and they cannot be used to monitor changes in governance levels for a given country. Moreover, these indicators are subject to very large measurement errors. To address this issue, they are usually reported together with confidence intervals. However, despite all the precautions taken in the publications, these indicators are sometimes misused in comparisons over time or time-series analysis. The World Bank also publishes country information through its country policy and institutional assessment, which is based on the World Bank staff's assessment, but only part of this is publicly available.

The composite and sub-indicators of Governance Matters indicators are now widely reported in the press and used in academic research. These indicators are timely and cover a wide range of countries. Transparency in the methodology and in the source used has significantly improved over the years. Since 2006, underlying data from virtually all the individual data sources are available so that it is possible to replicate the data.

Governance indicators are strongly correlated with the current level of national income per capita (Table 3, Figure 1), whether the sample covers the world or is restricted to the OECD. By contrast, correlations between those indicators and GDP per capita growth are much lower and sometimes not significant. This is consistent with the concepts of absolute and conditional convergence (Barro and Sala-i-Martin, 1991; Sala-i-Martin, 1995; Furceri, 2006). Correlations should nonetheless be interpreted with caution as they do not control for the effects of additional variables.

Table 3. **Correlation between governance indicators and GDP per capita**

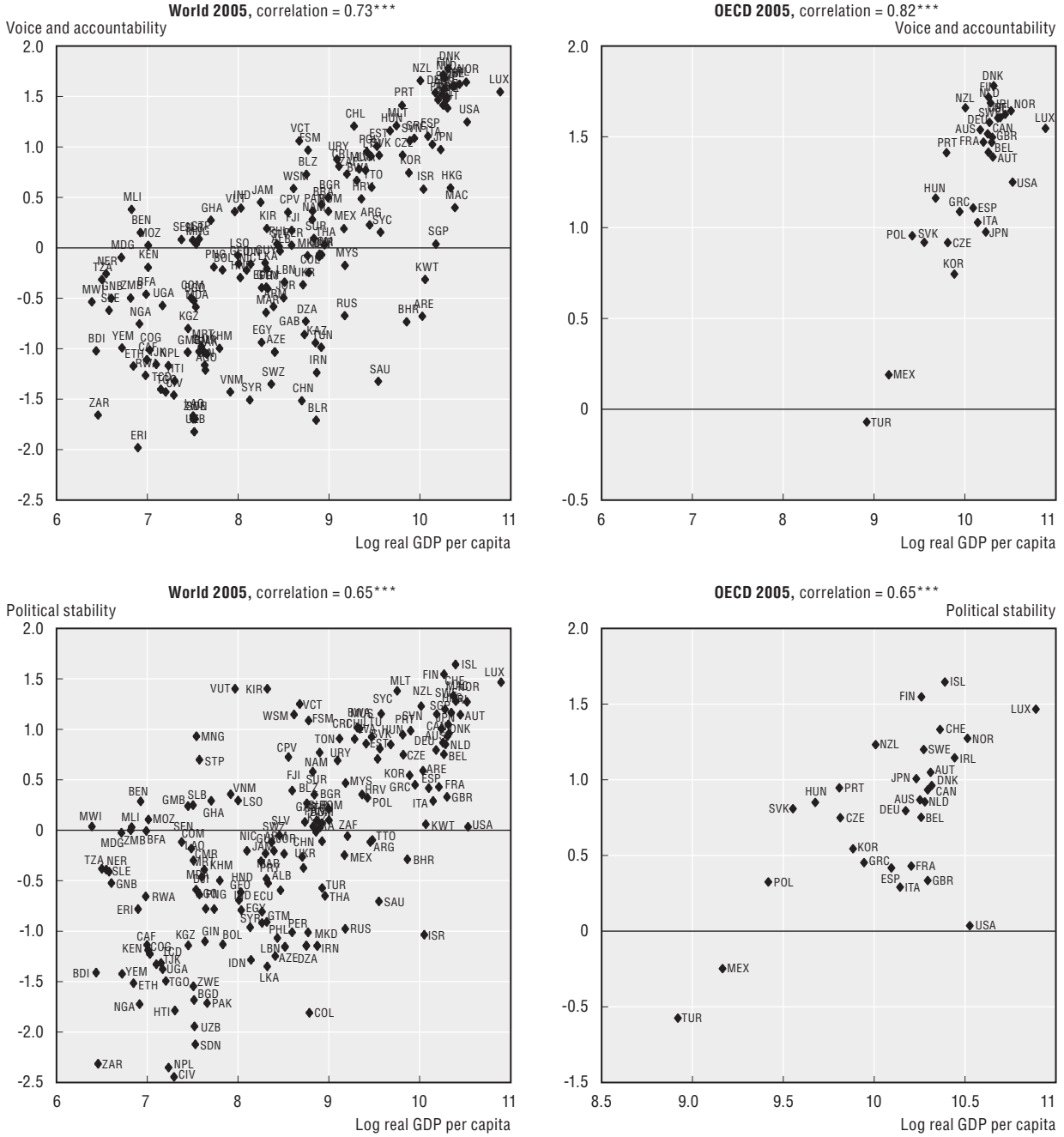
	log (GDP per capita)		Year
	World	OECD	
Voice and accountability	0.73***	0.82***	2005
Political stability	0.73***	0.82***	2005
Government effectiveness	0.87***	0.84***	2005
Regulatory quality	0.84***	0.85***	2005
Rule of law	0.83***	0.86***	2005
Control of corruption	0.82***	0.81***	2005
Corporate Illegal corruption	0.75***	0.8***	2005
Corporate legal corruption	0.52***	0.69***	2005
Bribe	–0.2***	0.01	2005
Corruption perception index	0.8***	0.8***	2005
Corruption (WDI)	–0.28***		2005
Property rights (doing business)	–0.53***	–0.2	2008
Political constraint (Henniz, 2006)	0.31***	0.29	2004
Polity IV	0.42***	0.7***	2005
State fragility Index	–0.88***	–0.46***	2001

Note: ***, ** and * denote significance at 1, 5 and 10%.
Source: OECD Secretariat.

However, the use of these indicators can be questioned on a number of grounds (Arndt and Oman, 2006):

- The indicators are inherently subjective and not grounded in theory. As a result, the same indicator can lead to very different interpretations.
- The data rely on a large variety of sources consisting of surveys of firms and individuals, as well as the assessments of commercial risk-rating agencies, non-governmental organisations and a number of multilateral aid agencies and other public sector organisations. The reliability of these sources is variable. In total the dataset draws on 33 sources.
- The indicators embody large measurement errors. For some developing countries, the indicator relies on a limited number of surveys, increasing further the risk of measurement error. To partially address these issues, confidence intervals around the main World Bank indicators are published. A change in an indicator over time is significant only when the confidence intervals of the new and old indicators do not overlap.
- The indicators do not permit the identification of trends over time. The changing composition of many of the indicators means that the indicator cannot be reliably used to compare levels of governance over time in a given country or among countries. This implies that monitoring of progress is not possible.
- The aggregation procedure assigns less weight to the sources that are less correlated with other sources. Typically, more weight is given to expert assessment and firm surveys than to population surveys, which often carry no weight. This suggests that measurement errors are uncorrelated across sources and are a questionable assumption. Moreover, weights attributed to different sources vary between countries, lowering cross-country comparability.

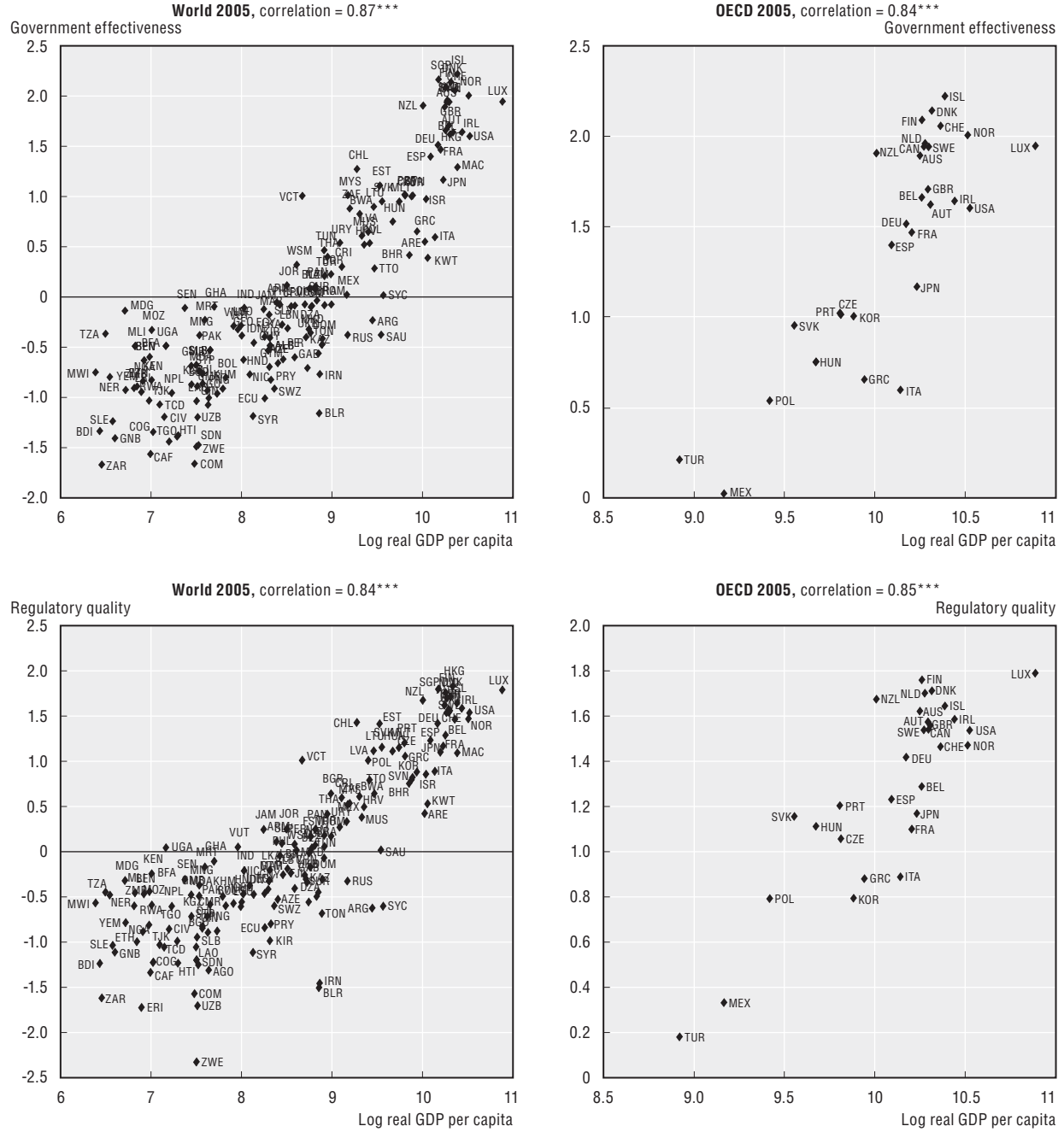
Figure 1. **Correlation between selected governance matters indicators and GDP per capita**



Note: ***, ** and * denote significance at 1, 5 and 10%.

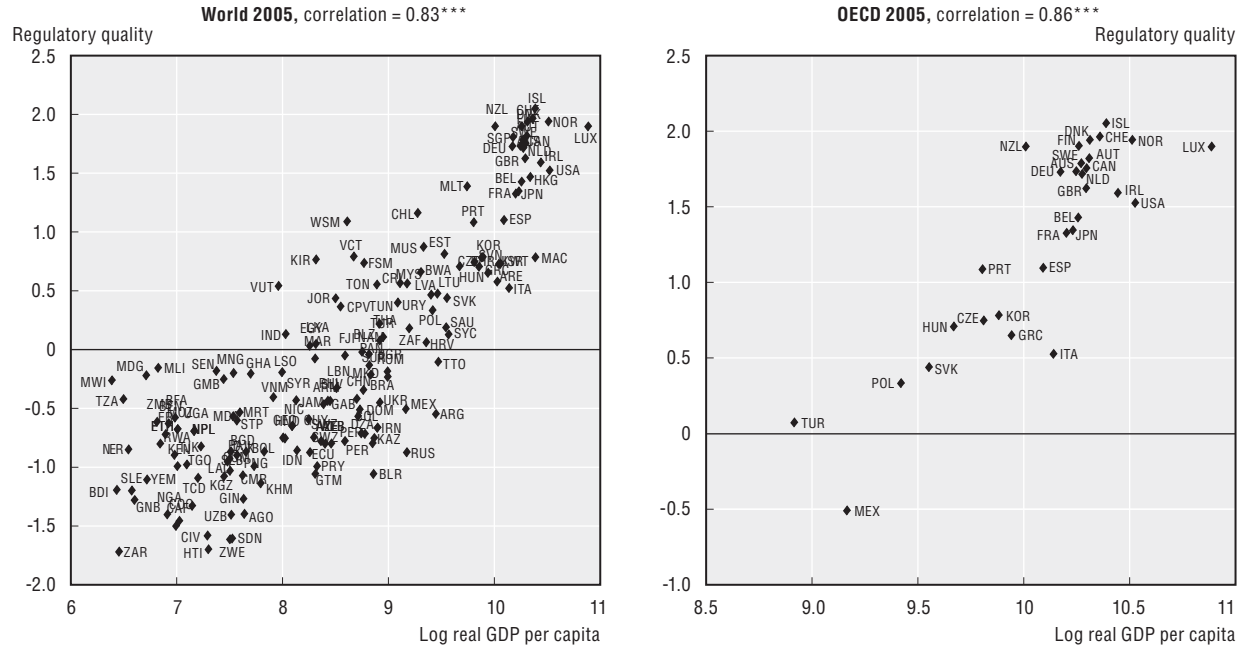
Source: World Bank.

Figure 1. **Correlation between selected governance matters indicators and GDP per capita** *(cont.)*



Note: ***, ** and * denote significance at 1, 5 and 10%.
Source: World Bank.

Figure 1. **Correlation between selected governance matters indicators and GDP per capita** *(cont.)*



Note: ***, ** and * denote significance at 1, 5 and 10%.
Source: World Bank.

2.1.2. Public finances and tax

Given the size of government and its role in the economy, the contribution of government to national economic growth is of great significance (Folster and Henrekson, 2001; Alfonso and Furceri, 2008). Moreover, transparent budgeting institutions foster debate between different alternative policies. However, there are few reliable sources of comparative public management data. To fill this gap, twice a year, beginning in 2009, the OECD has published *Government at a Glance*. Information on the budget process, decentralisation and public sector efficiency has been gathered through questionnaires collected by the OECD. In addition, composite indicators measuring compliance with OECD good practice for the quality of regulatory management systems, according to 16 dimensions, have been calculated. The indicators rely on a principal component analysis using 1998 and 2005 data, and have then been interpolated to cover the period 1998-2006. The data will be updated using the 2008 questionnaire. Data are available for all OECD countries except Luxembourg, Poland and Slovakia, and are subject to peer review. The first component of the principal component analysis gathers information on institution, tool and capacity building, and preliminary results suggest that this indicator is well correlated with economic outcomes such as employment, GDP or labour productivity.

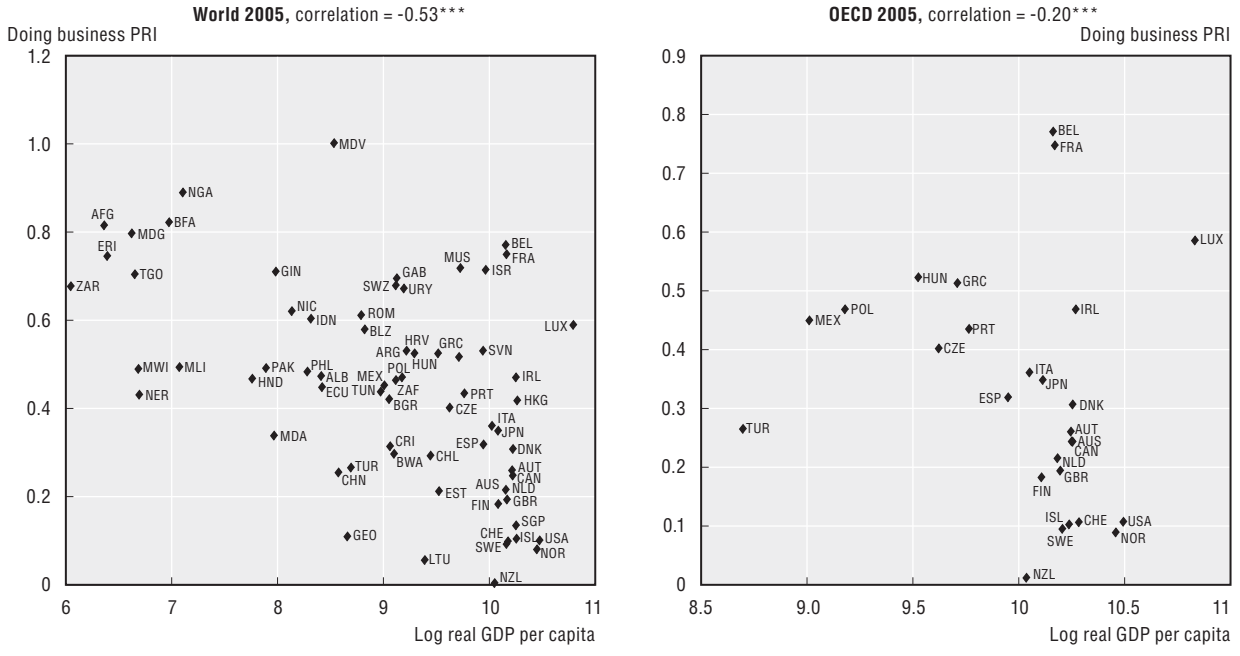
Another promising project to measure the quality of public finances along several dimensions is under way at the European Commission. Some composite measures have also been developed by the Centre of Budget and Policy Priorities (open budget index) and the Heritage Foundation (fiscal freedom), but their simplicity renders their interpretation difficult. Finally, the World Bank has constructed a perception-based indicator of government effectiveness in its Governance Matters publication.

The structure of tax systems also matters for growth (Johansson *et al.*, 2008; Arnold, 2008). A lot of data are available on the structure of the tax system, its efficiency and its redistributive impact (at least for some types of tax) in OECD publications. Updated information on the level and the structure of tax is available in *Tax and Benefit* and in *Revenue Statistics* for OECD countries. This includes standard data on corporate, income or consumption tax revenue and rates. More sophisticated indices such as the C-efficiency index, which seeks to capture the efficiency of consumption tax, are also constructed at the OECD. Information on tax rates can also be found in the OECD tax database, but the country coverage is usually limited and corporate rates are available only for specific groups of firms.

2.1.3. Property rights

Property rights refer to the degree to which private property is protected by institutions and policy. The overall effect on investment remains an empirical question. Moreover, the cost of reforming property rights can be high and can slow the reform process. Several measures of property rights are available. The Heritage Foundation index is the most widely used and is an assessment of the degree to which the country protects property rights and facilitates private contracting. Other indicators of property rights are commonly used in the literature, such as the indicator of protection against the risk of expropriation from the International Country Guide Risk. An indicator of investor protection is also available in the World Bank's Doing Business data base. This indicator is updated every year, covers a large number of countries and is based on official or quasi-official sources. The data are also subject to peer review. It is correlated with the level of GDP per capita, but the coefficient of correlation is small, especially when the analysis is restricted to the group of OECD countries (Figure 2). In addition, the Doing Business data

Figure 2. **Correlation between doing business (property rights) and GDP per capita**



Note: ***, ** and * denote significance at 1, 5 and 10%.

Source: World Bank.

base focuses on specific geographical areas and types of firms, and may thus not be fully representative of property rights at the national level. Among indicators of property rights, the development of new technology has focused attention on intellectual property rights. Indeed, strong perceived property rights encourage firms to invest, but at the same time may slow the diffusion of technology. The first indicator of intellectual property rights was developed by Ginarte and Park (1997).

2.1.4. Political institutions

Political institutions, including the type of regime or the electoral system, through their effect on the country political stability and/or government spending, are also crucial in investment decisions and long-term growth. Coding on the form of government and measure of government stability is currently available in many databases. In particular, the Polity IV project and the World Bank Database on Political Institutions gather updated information on a large set of countries. Other frequently used indicators cover civil and political rights and are based on expert assessments.

The Polity IV data set has a broad geographical and temporal scope. The correlation with the level of GDP per capita for countries is significant but not high. Each annual update of the Polity data series includes a systematic re-examination of country coding over the previous five years and a review of cases that have raised concerns and resulted in specific inquiries by data users. The underlying methodology is transparent. The construction of the overall Polity IV indicator ultimately relies on points that are assigned to qualify certain features of the political system *(e.g.,* on competitiveness of executive recruitment). This has the benefit of ensuring an equal treatment across countries and comparability over time, but also means the weights are arbitrarily imposed.

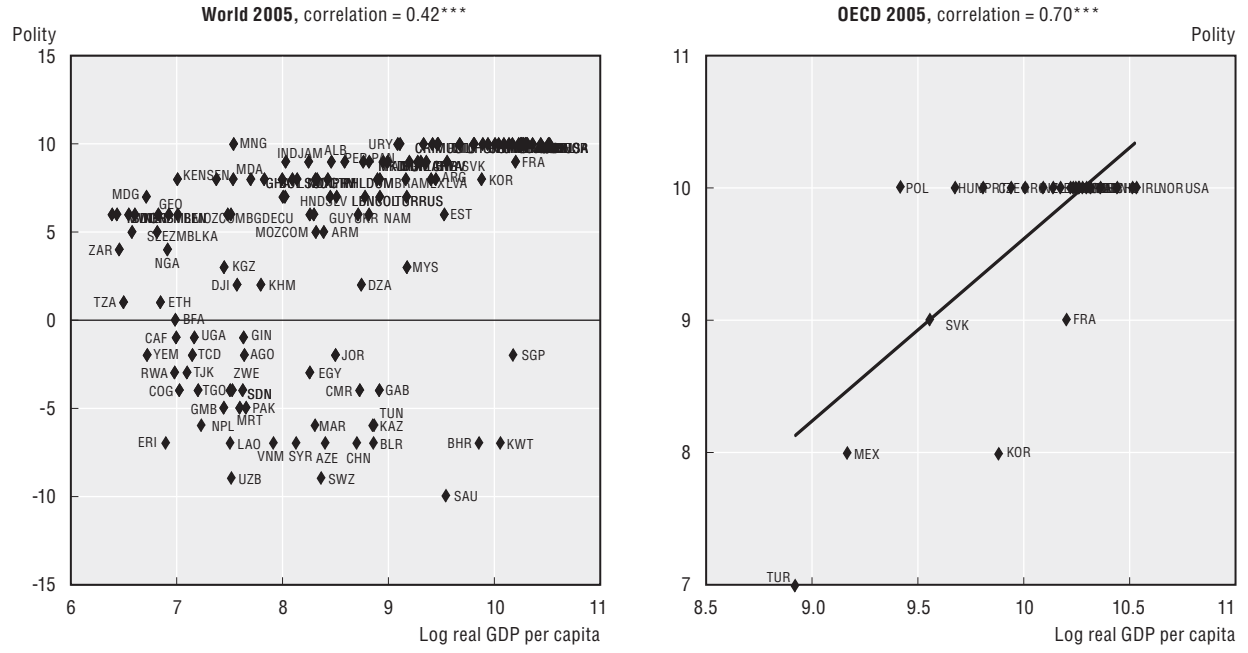
The World Bank's Database on Political Institutions data set contains objective information on different features of the political system and electoral rules. It is based on official sources. The more aggregate variables in this data base code the political regime using only three categories: direct presidential, strong president elected by assembly and parliamentary. These indicators may not be sufficiently precise to help in discriminating between political systems in OECD countries (Figure 3).

2.1.5. Corruption

Another strand of governance indicators has sought to measure corruption, *i.e.,* the abuse of public office for private gains. This is an outcome of poor governance. It is found to influence a number of fundamental economic aggregates (Lambsdorff, 1999). In particular, corruption discourages private investment and distorts resource allocation. Reducing corruption is also found to have positive side effects, such as increasing the effectiveness of public spending. But measuring corruption is difficult, as those with direct knowledge of corruption are likely to keep silent about it. In particular, the extent to which political decisions are influenced by corruption is very difficult to estimate, as it lies outside the direct experience of citizens and small businesses.

A wide range of perception-based corruption indicators are currently available, using information from expert and business surveys. Two indicators are worth mentioning: the Corruption Perception Index (CPI) from Transparency International and the control of corruption index from Governance Matters. In response to the criticism that corruption indicators underestimate the extent of corruption in developed economies, Kaufmann *et al.* (2008) have also assessed the importance of legal[1] and illegal corruption. Both the CPI

Figure 3. **Correlation between Polity IV political indicator and GDP per capita**



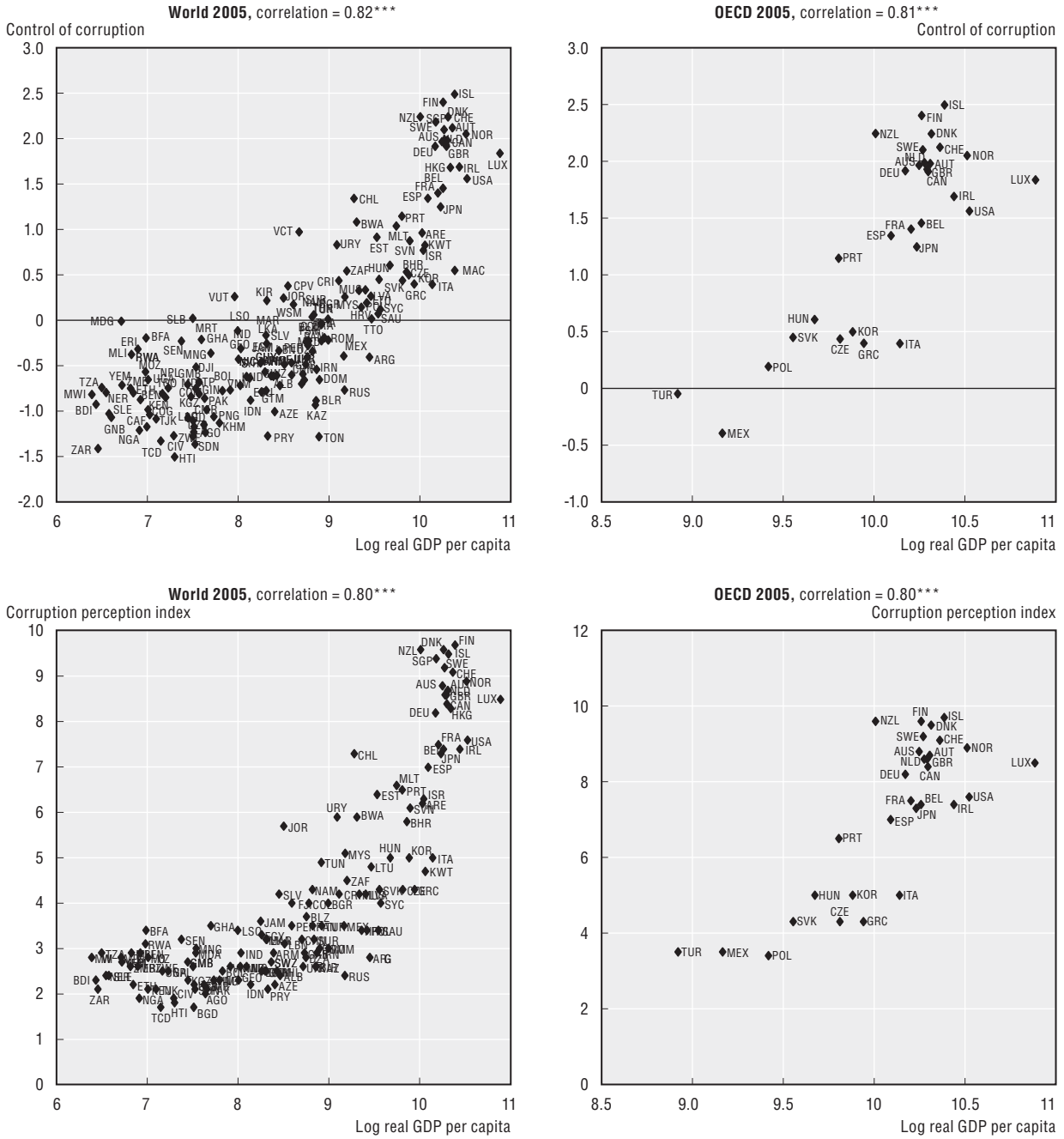
Note: ***, **and * denote significance at 1, 5 and 10%.

Sources: Polity IV project and World Bank.

and the control of corruption indicators are timely and appear well correlated with the level of GDP per capita, although clear income threshold effects are visible (Figure 4). The control of corruption index suffers nonetheless from the same limitations as the other indicators of Governance Matters (see above).

The corruption perception index from Transparency International is probably the most widely used and the one with the broadest geographical coverage, though the coverage can vary over time. It is a subjective index. Despite its label, this indicator does not measure the actual level of corruption, but provides a country ranking according to the degree of perceived corruption among public officials and politicians. The indicator is published together with standard errors, casting some light on the uncertainties surrounding the data. Information on its methodology and sources is easily accessible. However, the measure lacks consistency over time. The sources used for the CPI are indeed sometimes discontinued over the years with no reason even though the source is available. Only two sources have been used in every year the index has been published. It is also difficult to interpret the year-on-year change of score in the CPI, which could reflect the fact that different points of view have been collected and different questions asked rather than a change in the reality of corruption in a country. According to Transparency International, the CPI measure is a ranking that cannot be used as a measure of corruption: indeed, it emphasised the rank ordering of countries over internal reforms in countries. This means that this indicator cannot be used as an indicator of reform effort. In addition, this indicator suffers from selection bias (OECD, 2006). Finally the indicator draws on 12 sources, with different degrees of reliability.

Figure 4. **Correlation between selected indicators of corruption and GDP per capita**



Note: ***, ** and * denote significance at 1, 5 and 10%.
Sources: World Bank, Transparency International.

2.1.6. Link with economic performance

The link between selected governance indicators and economic growth, or other measures of economic performance, has been examined in depth (Easterly, 2005). In general, high-quality governance institutions are found to matter for economic performance (Table 4). However, the direction of causality is not always clear: "deep" institutions are also highly endogenous, and it is not at all easy to identify their causal role

with respect to income levels or economic growth (Glaeser *et al.*, 2004; Acemoglu *et al.*, 2005). Moreover, the role of geographic factors and trade openness appears to be closely interrelated with institutions, making their identification difficult (Rodrick *et al.*, 2004; Boulhol and de Serres, 2008). In addition, there appear to be important threshold effects, with good institutions *(e.g.,* the absence of corruption) having very little effect at the two extremes of the income scale. Finally, it should be noted that the nature and limits of composite governance indicators are not always fully grasped by users, weakening the rigour and credibility of many studies. In addition, the results found in the literature are usually sensitive to changes in the econometric model used, to the variables included and to the underlying assumptions.

Table 4. **Governance and economic growth**

Institutional factors	Indicator or methodology and main results
North (1990, 2005)	Indicator: Formal and informal institutions (culture and unwritten values) The paper demonstrates the importance of a system of governance and its interaction with the behaviour of economic and political organisations for long-term economic growth, enhancement of human welfare and societal development.
Globerman and Shapiro (2002)	Indicator: Aggregate of the six Governance Matters indicators Countries that fail to achieve a minimum threshold of effective governance are unlikely to receive much FDI, and above that threshold the quality of governance infrastructure is an important determinant of the amount received.
Kaufmann and Kraay (2002)	Indicator: Six Governance Matters indicators Good governance tends to promote growth. However growth, *per se*, does not tend to promote better governance.
Kaufmann *et al.* (2008)	Institutions appear to play an important role in economic development, and countries with higher levels of GDP per capita have *much* higher quality institutions, according to many measures.
Johansson *et al* (2008)	Methodology: Macro- and micro-based analysis The structure of the tax system has an impact on growth.
Property rights	
Jaumotte and Pain (2005)	Indicator: Cross-country index of intellectual property rights developed in Ginarte and Park (1997) and updated in Park and Singh (2002) Intellectual property rights have little effect on R&D spending.
Knack and Keefer (1995); Mauro (1995); Acemoglu, Johnson and Robinson (2001)	Less secure property rights are correlated with lower aggregate investment and slower economic growth.
Political factors	
Przeworski *et al.* (2000)	Indicator: Use objective criteria for distinguishing on a yearly basis between democratic and non-democratic governments (with two sub-categories: authoritarian and bureaucratic dictatorship) for 141 countries between 1950 and 1990 Democratic and non-democratic governments tend to grow on average at the same rate, but population grows faster in non-democracies so that GDP per capita grows more rapidly in democracies. Existence of a poverty trap: in the poorest countries, democracy makes no difference to economic growth.
Persson and Tabellini (2004)	Constitutional rules shape economy policy.
Persson and Tabellini (2003)	Methodology: Panel data from 1960 covering about 500 elections in over 50 democracies A broad classification of electoral rules into proportional and majoritarian does not seem to be strongly correlated with economic performance. It appears nonetheless that a parliamentary form of government is associated with better performance and better growth-promoting policies, measured by indexes for broad protection of property rights and of open borders in trade and finance. The negative effect of presidentialism is present only among the democracies with lowest scores for the quality of democracy. The authors classify countries in two groups according to the electoral formula and estimate the extent of electoral cycles in different specifications, including fixed country and time effects as well as a number of time-varying regressors. Governments in democracies that use plurality rule cut taxes and government spending during election years — the magnitude of both cuts is of the order of 0.5% of GDP. In proportional representation democracies, tax cuts are less pronounced, and no spending cuts are observed.
Milesi-Ferretti, Perotti and Rostagno (2002); Persson and Tabellini (2003, 2004);	Relying on different data, these papers show that a statistically significant (but smaller) effect of the electoral system remains after controlling for other determinants of social security and welfare spending, such as the percentage of the elderly in the population, per capita income and the age and quality of democracy.
Gradstein (2008)	Method: Theoretical model Low-quality institutions, concentration of political power and material wealth and underdevelopment are persistent over time. The possibility of two developmental paths is exhibited: with concentration of political and economic power, low-quality institutions and slow growth; and a more equal distribution of political and economic resources, high-quality institutions and faster growth.

Table 4. **Governance and economic growth** *(cont.)*

Institutional factors	Indicator or methodology and main results
Marshall and Cole (2008)	Indicator of state fragility A fairly strong relationship is found between income and the fragility of states in the global system. However, a wide variance in fragility scores at any level of incomes is also observed.
Corruption	
Lambsdorff (1999)	Method: Overview of the literature Corruption affects a variety of economic indicators such as government expenditures, total investment, capital flows and foreign direct investment, international trade, foreign aid and GDP per capita.
Kraay and Nehru (2004)	Indicator: CPIA indicators from 1997 to 2001 Significant inverse correlation between the quality of a country's institutions and probability of debt distress.
Welsh (2008)	Indicator: Transparency International average perceived corruption indicators This article uses self-rated subjective well-being as an empirical approximation of general welfare and shows that cross-national welfare is affected by corruption not only indirectly through GDP, but also directly through non-material factors.
Kaufmann *et al.* (2008)	Indicator of legal corruption Governance and corruption issues are key constraints to investment and business and are particularly significant in assessing countries' overall positions.

Source: OECD Secretariat.

2.2. Society

2.2.1. Health

Health can affect growth through several channels. First, health affects labour productivity, since healthier workers can work harder and for a longer period of time. Second, health favours human capital accumulation, since healthier students on average have higher cognitive functioning. Third, health encourages physical capital accumulation, since healthier workers who work for a longer period of time increase saving (for retirement) and thus investment, and since the increase in labour input from healthier workers will increase the marginal product of capital. Fourth, health influences population growth.

Health indicators can be subdivided into policy and outcome indicators. Health policy indicators are a combination of health care resources, lifestyle and socio-economic factors.[2] Health care resources usually are separated into monetary resources (public spending on health) and non-monetary resources (number of physicians, hospitals, medical machinery, *etc.*). While from a theoretical point of view health care resources are positively linked to health outcome indicators, the evidence is not conclusive from an empirical point of view.[3] In contrast, socio-economic factors (such as education) and lifestyle factors (tobacco, alcohol and nutrition) have been found to be strongly related to health outcomes. Data on health policy indicators are easily accessible and can be used to assess their impact on health outcomes (see the annex in Furceri and Mourougane, 2009). However, they suffer from endogeneity problems in relation to outcome indicators and GDP growth. Thereby, they have to be used very carefully in that context.

Outcome indicators aim to measure health outcomes. Those that have been usually considered in the literature are: mortality/longevity indicators (life expectancy at various ages), mortality indicators adjusted for the presence of a particular disease and quality of life, and other health-related indicators, such as public satisfaction for the health care system.[4] Different international organisations such as the OECD, World Health Organization and World Bank publish data on many of these outcome indicators, and data are available for a long timespan. The variable that has been used most in the literature on health and growth is a performance measure, life expectancy at birth. Data on life expectancy are available from official sources (OECD, IMF, World Bank, Eurostat and WHO)

and over a large timespan and for a broad set of countries. Quality-adjusted life years have been developed to refine gross measures of health outcomes such as life expectancy, but they are not exempted from methodological problems.

These indicators have been found in many studies to be positively linked to GDP per capita, GDP growth and total factor productivity (TFP) growth, although it is unclear in which direction the causality goes (Table 5).[5] On the one hand, life expectancy at birth clearly improves when living standards increase, but on the other hand life expectancy at birth can raise incentives to invest in education and increase labour supply if it extends the working life. The latter effect could be particularly important in economies where the population is ageing rapidly. Although micro studies based on individual and household data found a positive link between health outcomes and economic performance, the evidence of a link at the aggregate level is much less clear for developed countries (Price *et al*. 2008; Dormont *et al*. 2008). The weaker evidence found for developed countries could be due to a non-linear relationship, positive at low levels of development and insignificant or negative at higher levels. Moreover, it should be noted that the use of these indicators to assess the impact on growth has to be dealt with carefully, since problems of endogeneity and omitted variable bias may arise.

Table 5. **Selected results on health and economic performance**

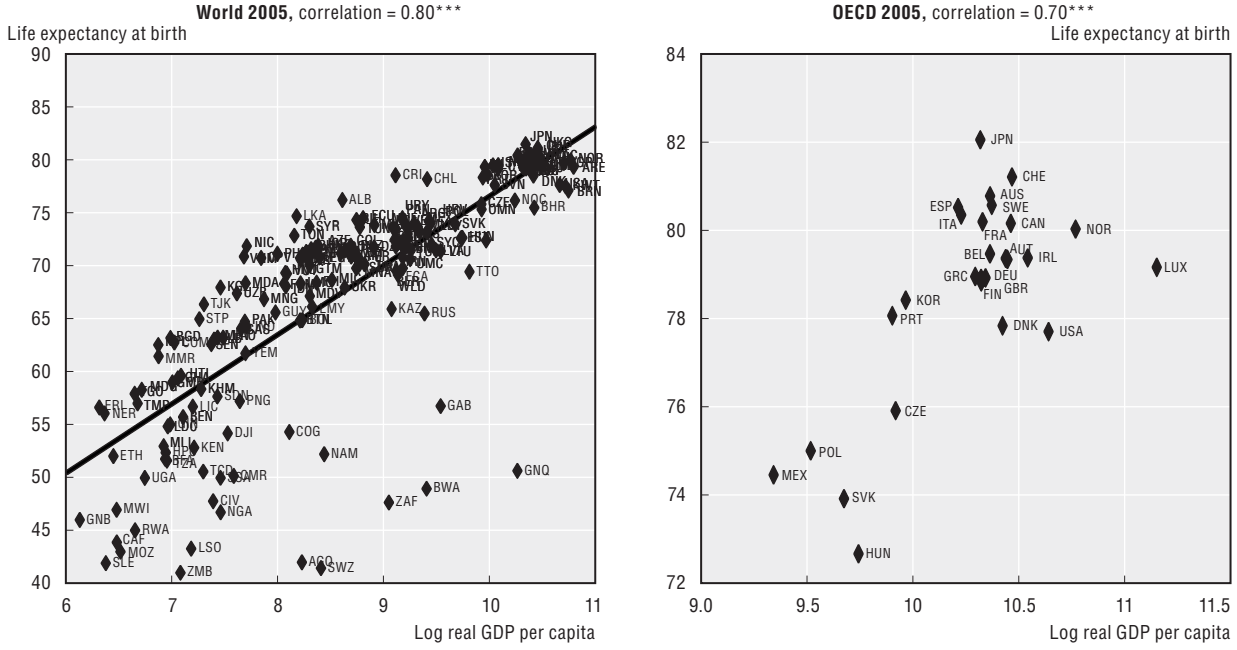
	Indicator or methodology and main results
Barro (1996)	Indicator: Life expectancy Main result: The paper shows significant effects of health on growth for a panel of 84 countries from 1965 to 1990. Methodology: 3SLS; controlling for human capital and other covariates
Barro and Lee (1994)	Indicator: Life expectancy Main result: The paper shows significant effects of health on growth for a panel of 90 countries from 1965 to 1985. Methodology: SUR and random effects; controlling for human capital and other covariates
Barro and Sala-i-Martin (1995)	Indicator: Life expectancy Main result: The paper shows significant effects of health on growth for a panel of 90 countries from 1965 to 1985. Methodology: SUR and random effects; controlling for human capital and other growth and governance covariates
Bhargava, Jamison, Lau and Murray (2001)	Indicator: Adult survival rate Main result: The paper shows significant effects of health on growth for a panel of 92 countries from 1965 to 1990. Methodology: Dynamic random effects; controlling for fertility and other growth covariates
Bloom, Canning and Malaney (2000)	Indicator: Life expectancy Main result: The paper shows significant effects of health on growth for a panel of 92 countries from 1965 to 1990. Methodology: Pooled OLS; controlling for working age and growth covariates
Bloom and Williamson (1998)	Indicator: Life expectancy Main result: The paper shows significant effects of health on growth for a panel of 78 countries from 1965 to 1990. Methodology: Pooled OLS; controlling for growth covariates
Caselli, Esquivel and Lefort (1996)	Indicator: Life expectancy Main result: The paper shows significant effects of health on growth for a panel of 91 countries from 1960 to 1985. Methodology: GMM; controlling for human capital
Finlay (2007)	Indicator: Adult mortality Main result: The paper shows significant effects of health on growth for a panel of 62 countries from 1960 to 2000. Methodology: 2SLS; controlling for human capital, fertility and other growth covariates

Table 5. **Selected results on health and economic performance** *(cont.)*

	Indicator or methodology and main results
Gallup and Sachs (2000)	Indicator: Life expectancy Main result: The paper shows significant effects of health on growth for a panel of 91 countries from 1960 to 1985. Methodology: GMM; controlling for human capital
Sachs and Warner (1997)	Indicator: Life expectancy and life expectancy squared Main result: The paper shows significant effects of health on growth for a panel of 97 countries from 1965 to 1990. Methodology: OLS; controlling for human capital, governance and growth covariates
Suhrcke and Urban (2006)	Indicator: Cardio-vascular disease Main result: The paper shows significant effects of health on growth for a panel of 74 countries from 1960 to 2000, especially for rich countries. Methodology: GMM; controlling for growth covariates

Source: OECD Secretariat.

Figure 5. **Correlation between life expectancy and GDP per capita**



Note: ***, ** and * denote significance at 1, 5 and 10%.

Sources: World Bank, OECD.

2.2.2. Education

Investment in human capital at all ages is crucial for long-term growth and is often considered as a prerequisite to development (Table 6).

Data on early education and childcare are available in the OECD Family database, though it is mostly limited to childcare support, public spending on childcare or enrollment. No indication on the quality of the services is currently available on a cross-country basis.

For primary and secondary education, the *OECD Education at a Glance* database is a rich source of information and is updated every year. These data can be complemented by UNESCO data for non-OECD countries. In addition, the Programme for International Student Assessment (PISA) score, which is based on a series of tests passed by 15-year-old

Table 6. **Selected results on education and economic performance**

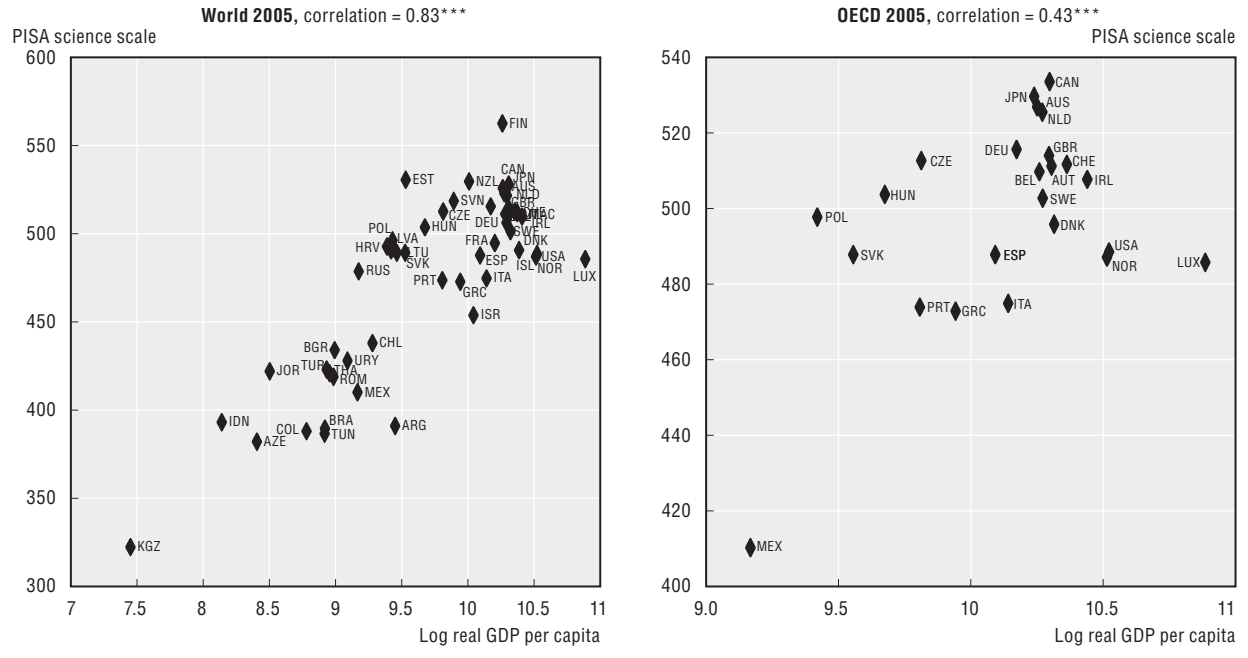
	Results
Barro (1991), Mankiw *et al.* (1992)	Educational factors have a positive impact on output levels.
Barro (1997)	An extra year of education raises economic growth by 1.2% per annum.
Toppel (1999), Oulton (1997)	The impact of an extra year of schooling is much smaller than in Barro (1997).
Harmond *et al.* (2001)	An additional year of schooling increases wages by around 6.5% across European countries.
Krueger and Lindhal (2001)	Find a significant effect of education on growth only for countries with the lowest level of education.
Cohen and Soto (2001), de la Fuentes and Domenech (2006)	Schooling indicators have an impact on standard growth specifications.
Hanuchek and Kimbo (2001), Coulombe (2004)	Using indicator of skills, the effect of education on output is found to be stronger than that estimated using attainment data.

Source: OECD Secretariat.

students, is now regularly published for different topics. The aggregate score is found to be well correlated with the level of GDP per capita, especially when developed countries are incorporated in the sample (Figure 6).

Investment in tertiary education is usually measured through indicators of education output (and not quality) such as enrollment, literacy, graduation ratios or the number of years of schooling. The main difficulty in using these data is generally their lack of comparability across countries. Harmonised graduation ratios have been produced by the OECD and UNESCO. Consistent time series for a relatively long period (usually 1991–2004) can be derived by combining these two sources. Data on international student enrollment can also be found in the UNESCO-OECD-Eurostat (UOE) data collection on education statistics. In addition, composite indicators have been built to measure supply-side factors,

Figure 6. **Correlation between PISA scores and GDP per capita**



Note: ***, ** and * denote significance at 1, 5 and 10%.
Sources: World Bank, OECD.

such as a summary measure of the institutional set-up of tertiary education, or demand-side factors such as the internal rate of return to education (Oliveira Martins *et al.*, 2007). These data are available for many OECD countries, but only for some years (2005–2006 for the supply-side indicator and 2001 for the internal rate of return).

2.3. Labour market

Labour markets matter for growth through their impact on both labour utilisation and, to a lesser extent, labour productivity. A very large body of literature has examined these effects from a theoretical and empirical point of view. In particular, institutions are usually found to affect the structural unemployment rate, although some of these results sometimes suffer from a lack of robustness (Table 7).

Table 7. **Labour market indicators and performance**

Indicator	Papers	Impact on structural unemployment
Unemployment benefits	OECD (2006); IMF (2003); Nunziata(2002); Jimeno Rodriguez-Palenzuela (2002); Nickel *et al.* (2003); Belot and van Ours (2001); Morgan and Mourougane (2005); Blanchard and Wolfers (2000); Daveri and Tabellini (2000); Fitoussi *et al.* (2000); Elmeskov *et al.* (1998); Nickell (1997,1998); Scarpetta (1996); Nicoletti and Scarpetta (1995)	Positive (sometimes significant in most but not in all cases)
	Macculloch and DiTella (2002); Baker *et al.* (2004); Bertola *et al.* (2002); Fiori *et al.* (2007)	No effect
Active labour market policies	OECD (2006); Fitoussi *et al.* (2000); Elmeskov *et al.* (1998); Nickell (1997,1998); Scarpetta (1996); Boone and van Ours (2004)	Negative (sometimes significant in most but not in all cases)
	Baker *et al.* (2004)	No effect
Union density and/or bargaining coverage	IMF (2003); Morgan and Mourougane (2005); Blanchard and Wolfer (2000); Nickell (1997,1998); Scarpetta (1996)	Positive
	OECD (2006); Macculloch and DiTella (2002); Nunziata (2002); Baker *et al.* (2002); Daveri and Tabellini (2000); Fitoussi *et al.* (2000); Elmeskov *et al.* (1998)	No effect or negative
Centralisation and coordination of wage bargaining	OECD (2006); IMF (2003); Nunziata (2003); Baker *et al.* (2002); Jimeno and Rodriguez-Palenzuela (2002); Nickell *et al.* (2003); Blanchard and Wolfer (2000); Fitoussi *et al.* (2000); Nickell (1997,1998); Scarpetta (1996); Nicoletti and Scarpetta (1995); Fiori *et al.* (2007)	Negative
	Macculloch and DiTella (2002); Belot and van Ours (2001); Bertola *et al.* (2001)	No effect or positive
EPL	OECD (2006); Baker *et al.* (2004); Nunziata (2003); Nickell *et al.* (2003); Belot and van Ours (2001); Morgan and Mourougane (2005); Daveri and Tabellini (2000); Nickell *et al.* (2002); Nicoletti and Scarpetta (1995); Fiori *et al.* (2007)	No effect or negative
	IMF (2003); Bertola *et al.* (2002); Jimeno and Rodriguez-Palenzuela (2002); Blanchard and Wolfers (2000); Elmeskov *et al.* (1998); Scarpetta (1996)	Positive
Labour tax wedge	OECD (2006); IMF (2003); Nunziata (2002); Baker *et al.* (2004); Jimeno and Rodriguez-Palenzuela (2002); Nickell *et al.* (2003); Belot and van ours (2001); Bertola *et al.* (2002); Morgan and Mourougane (2005); Blanchard and Wolfer (2000); Daveri and Tabellini (2000); Elmeskov *et al.* (1998); Nickell (1997, 1998); Nicoletti and Scarpetta (1995)	Positive
	Macculloch and DiTella (2002); Fitoussi *et al.* (2000); Scarpetta (1996); Fiori *et al.* (2007)	No effect

Source: OECD Job Strategy.

Both policy and outcome indicators have been developed to monitor labour markets and are already well covered in the literature and in works published by international organisations (such as *Going for Growth* published by the OECD). Policy indicators produced at the OECD cover a vast range of labour market institutions ranging from employment protection legislation to data on trade unions. These data are generally available for specific years only and suffer from serious limitations *(e.g.*, EPL measure is a *de jure* measure and does not reflect effective employment protection). These data are usually constructed only for OECD countries and sometimes for large non-member countries. Other institutional variables such as unemployment benefit generosity or replacement rates are more timely but usually constructed for certain household or worker types. By contrast, a lot of detailed information is available for OECD countries and over a long time span on active labour market policies and labour taxes. Marginal effective tax rates are also regularly computed for different household types. Data on minimum wages are available in the OECD minimum wage database for countries that have a national statutory minimum wage.

Other international institutions also publish data on labour market institutions. A large set of institutional variables is collected in the European Commission's LABREF database and the ILO Laborsta database. Qualitative information on the wage system is freely available on the EIRO website. Perception-based measures on worker motivations and industrial disputes can also be found in the *Global Competitiveness Report* which is updated every year. In addition, time series for selected institutional data such as EPL have been constructed by Allard (2005) and Amable *et al.* (2007), but the method applied to construct these indicators is questionable.[6]

Outcome indicators include data on employment, unemployment, hours worked and labour force participation. Data are usually fact-based, timely and have broad country coverage. Efforts have been made over the years to harmonise the data across countries. Moreover, a breakdown by gender, age, skill and sector is also available. The structural (or equilibrium) unemployment rate is a different type of outcome indicator as it is non-observable. It can be estimated using different methodologies, *e.g.,* the OECD Economics Department uses a core price Phillips curve and Kalman filter technique. Indicators of the implicit tax on retirement have also been developed and regularly updated by the OECD.

2.4. Product markets

Well-functioning product markets affect positively productivity and consumer welfare through various channels (Table 8). Indeed, competition in product markets boosts efficiency in three ways. First, it enhances allocative efficiency. Second, productive efficiency or x-efficiency, *i.e.,* the ability of firms to produce output at minimum resource costs, can also be increased. Third, competition influences the incentives to innovate and invest, so-called dynamic efficiency. In addition, increased competitive pressures can spur employment growth. At the same time, regulations are important to address market failures stemming, for instance, from asymmetries of information and externalities. But they also increase firms' compliance costs.

A large number of indicators have been developed to measure access to markets and the degree of competition. They are usually based on questionnaires and can be either perception- or fact-based. Although they are usually considered as policy indicators, composite measures sometimes aggregate policy and performance sub-indicators.

Table 8. **Product market indicators and economic performance**

	Results
Nicoletti *et al.* (2001), Blanchard and Giavazzi (2003), Baissanini and Duval, Griffith *et al.* (2007)	Anti-competitive product market regulations have significant negative effects on employment rates.
OECD (2003a), Aghion and Griffith (2005), Conway *et al.* (2006), Arnold *et al.* (2008), Nicoletti and Scarpetta (2005), Scarpetta and Tressel (2002), Fiori *et al.* (2007)	Anti-competitive product market regulations are negatively associated with productivity performance.
Bayoumi *et al.* (2004)	Greater competition produces significant effects on macroeconomic performance, as measured by standard indicators. It may also improve macroeconomic management by increasing the responsiveness of wages and prices to market conditions. Finally, greater competition can generate positive spillovers to the rest of the world through its impact on the terms-of-trade.
Bassaini and Ernst (2002)	Positive impact of deregulation on R&D activity
Scarpetta and Tressel (2002)	Strict regulation hinders the adoption of exiting technologies, possibly by reducing competitive pressures, technology spillovers or the entry of new high-tech firms.
Bartelman *et al.* (2003)	Deregulation has a positive impact on the expansion of successful firms.

Source: OECD Secretariat.

Among the policy indicators, the World Bank *Doing Business* report has attracted a lot of attention because of its broad country coverage and its annual updates. Its objective is to track reforms aimed at simplifying business regulations, strengthening property rights, opening up access to credit and enforcing contracts by measuring their impact on ten indicator sets. The indicators are then aggregated into an overall ranking comparing ease of doing business across countries. One of the main advantages of this database is that the methodology is transparent, data are comparable across countries and easily replicable, and reliability checks are done through the production process. However, the data may not be fully representative of the extent of regulation at the national level, as they focus on some specific regions or types of firms. Some data on administrative burdens and labour market institutions have been criticised as being too rough. In addition, some of the data are perception-based. The data also cover only domestically owned, limited-liability companies and a limited set of transactions. Moreover, it is assumed that firms have full information on requirements and procedures, and the data may underestimate firms' compliance burden.

Another well-known indicator is the Product Market Regulation (PMR) indicator published by the OECD, and its sectoral time-series variants. These are composite indicators summarising information on laws and regulations, as well as the compliance burden born by firms. These indicators are already extensively used in the context of multilateral structural surveillance, in the *Going for Growth* report or in country *Economic Surveys*. They have also been extensively used in academic research. They are based on a combination of responses to a questionnaire filled in by country officials and external data sources. The data are thus fact-based and highly transparent so that it is possible to reproduce the score of the indicator from the results used to derive it. The final outcomes, as well as the underlying data and the methodology, are subject to peer review. The weighting procedure has recently been simplified but comparability over time has been ensured through the construction of past data using the same methodology. Moreover, confidence bands are provided, helping the users to assess the reliability of the data. The data are updated every two to three years, usually with improvements in the methodology. Lately non-tariff data in the service sector have been included and complement the tariff data already included in the PMR indicator. The country coverage has been extended over the years and now also covers China and India. Looking forward, the indicator will be

enriched by the integration of the indicator of sectoral regulator independence which is found to be closely related to investment in infrastructure (Sutherland *et al.*, 2009).

The Business Competitiveness Index (BCI) produced by the World Economic Forum is a composite indicator constructed using a combination of survey and hard indicators, including a measure of intellectual property protection and the stringency of environmental regulation. Their focus is on capturing factors that matter for competitiveness at the micro-economic level. The construction process is fully transparent. However, the selection of the different indicators is nonetheless not straightforward and some may be strongly inter-correlated *(e.g.,* intellectual property protection and property rights). Finally, the weights are determined using factor analysis at a lower level of aggregation and regression on GDP per capita at a higher level of aggregation. It is unclear whether the ranking from the BCI is robust to an alternative weighting choice. Finally, there is no information on measurement errors.

Overall, past analysis points to a strong correlation between these various indicators for OECD countries. The correlation between the ease of doing business and the OECD product market regulation indicator is 0.7.

A new indicator is the questionnaire-based measure of whether a sector is subject to incentive price regulation, generally in the form of a price cap,[7] constructed by the OECD. The indicator is available for all OECD countries except Poland and Greece over the period end 2007 to early 2008. The sectoral coverage varies across countries. Thus far there is no plan to update the questionnaire. The methodology is transparent and the data have been subject to peer review. There is evidence that this indicator has a positive impact on investment in infrastructure in the presence of an independent regulator (Sutherland *et al.*, 2009), even though the indicator does not account for quality changes in infrastructure. Indicators summarising the main features of the regulatory institutions have been constructed in Høj (2007a). The indicators cover both general and sector-specific competition polices.

A large number of outcome indicators *(e.g.,* firm creation and destruction) are also available but most of the time at a national or sectoral level and updated only infrequently. Indices of concentration (such as the Herfindal index) are sometimes computed, but not on a regular basis or for a sufficient number of countries. Mark-ups have also been developed in OECD studies and elsewhere (Høj *et al.*, 2007b).

2.5. Infrastructure

The impact of infrastructure on output (and output growth) is difficult to pin down and the direction of causality hard to determine empirically (Table 9). However, there is some empirical evidence that investment has positive effects that go beyond the impact to be expected from a larger capital stock (Sutherland *et al.*, 2009). In particular, infrastructure investment appears to have on average a stronger long-term effect on growth at lower levels of provision, though the effect is different between developing and developed countries. It should be noted, however, that the definition of infrastructure varies from one study to another.

Data on infrastructure available over a relatively long time period and comparable across countries are scarce. Capital stock data published by national statistical offices lack harmonisation. They can usually be complemented by physical measures of infrastructure

Table 9. **Infrastructure and economic performance**

	Results
Ford and Poret (1991)	Infrastructure can have a growth-enhancing effect but the relation is weak and unstable.
Bonaglia *et al.* (2000)	Infrastructure makes a positive contribution to productivity in some Italian regions.
Kozerec *et al.* (2001)	There is a strong positive contribution of telecom and electricity, gas and water to productivity in the United States and Europe.
Sutherland *et al.* (2009)	There is evidence that infrastructure has a positive effect that goes beyond the expected impact from capital stock.
Hurlein (2006), Bougheas *et al.* (2000), Sutherland *et al.* (2009)	There is evidence that the link between infrastructure and growth is non-linear.

Source: OECD Secretariat.

provision, but the latter cannot be easily aggregated. Moreover these measures fail to capture the quality of infrastructure.

A composite indicator measuring how countries exploit the potential benefits of Public and Private Partnerships (PPPs) have recently been developed by the OECD. The data are available for 19 countries, though not for the United Kingdom, which has made extensive use of PPPs in the past. Data are questionnaire-based. No update is, however, currently planned.

2.6. International trade

The last three decades have witnessed rapid economic integration. This has spurred the development of economic analysis on the effects of trade on growth and living standards, both from a theoretical and an empirical point of view.

From a theoretical point of view, there are different channels through which trade can stimulate growth and improve living standards. First, according to the theory of comparative advantages, trade based on specialisation increases domestic output due to higher productivity. Second, trade is a means to increase worldwide competition in production and to enhance efficiency. Third, trade guarantees a greater choice of products. Fourth, it expands potential markets and permits domestic firms to take advantage of economies of scale. Fifth, trade allows the diffusion of knowledge and technological innovation.

From an empirical point of view there is a large literature showing that economies that are more open to international trade have higher rates of growth, as a result of higher investment, human capital accumulation, higher technology diffusion and sustained gains in factor productivity.[8]

These empirical works, however, differ in the approach of measuring trade openness. In particular, it is possible to classify the empirical research investigating the relation between trade and growth in two branches: those that use policy indicators as measures of trade openness, and those that use outcome indicators (in terms of trade intensity).

Trade policy indicators describe the institutional features of a country's attitude toward the rest of the world. The most common policy indicators are tariff barriers (or the effective tariff). However, there are many different policy instruments, *i.e.,* non-tariff barriers (such as quotas, exemptions, special permits and discriminatory practices) which can affect trade and which can be considered a better proxy for trade openness, especially in developed countries.[9] Thus, other indicators such as the one provided by the Heritage Foundation, Sachs and Warner (1995) and Wacziarg (2001) have used both tariff and

non-tariff barriers to construct an indicator for trade openness. The main advantage of these indicators is the (almost) absent problem of endogeneity with respect to growth. In contrast, the main limitation is their limited availability, and the fact that they usually reflect the legal framework in which agents operate, but not the effective degree of protection they face.

A policy indicator of trade openness has been constructed by the Heritage Foundation. The indicator is transparent in the way it is constructed and data are available for a very broad set of countries (161) from 1995 to 2007, based on well-documented sources.[10] The indicator is based on both trade and non-tariff barriers. While this has an advantage over other indicators based exclusively on tariff barriers, it has the main disadvantage that non-tariff barriers are difficult to construct and often require subjective judgments. However, the indicator is positively correlated with outcome indicators such as GDP's share of total exports and imports, and it shows a strong and positive correlation with GDP per capita.[11] This suggests that the indicator is reliable (measures what it pretends) and matters for living standards.

An alternative would be to restrict the construction of the indicator to tariff barriers. The OECD collects tariff data for most of its member countries. However, the outcome does not seem to be well correlated with openness, suggesting that abstracting from non-tariff barriers would lead to a serious bias and lower the usefulness of the data.

Another policy indicator is the FDI restrictiveness index constructed by Golub (2003) and updated in Koyama and Golub (2006). The indicator is available for OECD economies and 13 non-OECD economies. It covers three categories of restrictions: limitations on foreign ownership, screening or notification procedures and management or operational restrictions.

Outcome indicators describe the volumes and values of existing trade. The outcome indicator that has been mostly used to investigate the relation between trade and growth is export growth (see Table 10) and the share of total exports and imports to GDP. Other indicators of the same type are the structure-adjusted trade intensity (which is the ratio of real imports plus real exports to real GDP, corrected for transportation costs, country size and country income) and the ratio of imports to aggregate consumption. These indicators are all fact-based, and easy to construct. Moreover, many international organisations collect data on exports and imports (differentiated by structure, destination and origin) and these indicators are easy to compute. The main drawback of this type of indicator is the endogeneity problem with respect to growth (Frankel and Romer, 1995).

Table 10. **Trade growth and economic performance: Effects of real export growth on real GDP growth**

Average coefficient value	0.220
Median coefficient value	0.189
Average t-statistic	3.460**
Maximum coefficient value	1.851
Minimum coefficient value	–1.433
Average standard error	0.021
Average 95% confidence interval	±0.042
Average Kurtosis distribution	11.502
Average skewness	–0.134

Note: **Significant at the 95% level. Based on 196 regressions.
Source: Lewer and Van den Berg (2003).

2.7. Financial markets

Financial markets influence capital accumulation and productivity growth through their intermediation role. They foster the efficient allocation of capital, facilitate international capital flows and allow the pooling of risks and spread of information about investment opportunities.

From an empirical point of view there is a large literature finding that economies with more developed financial markets have higher rates of growth. In particular, according to cross-country comparisons, individual country studies as well as industry- and firm-level analyses, a positive link exists between the sophistication, the depth and the effective functioning of the financial system and economic growth (see Table 11).

To assess the effect of financial markets on economic growth, two sets of indicators have been used: policy indicators and outcome indicators.

Financial policy indicators try to measure aspects of domestic and financial markets mostly related to the regulatory stance, as regards stability, competition and liberalisation. The main advantage of these indicators is the (almost) absent problem of endogeneity with

Table 11. **Financial markets and economic growth**

	Indicator used or methodology and results
De Serre *et al.* (2007)	A set of indicators of banking and regulation created from the World Bank Regulation and Supervision database for 25 OECD countries Regulation that is more conducive to competitive and efficient financial markets has a positive impact on output and productivity.
Atje and Jovanovic (1993) and Levine and Zervos (1998)	Stock market trading as a share of GDP Positive correlation between stock market trading and growth
Levine (1998, 1999) and Levine *et al.* (2000)	Use GMM and a country's legal origin as an instrument for financial development Establish a causal link between finance and growth
Aghion *et al.* (2005)	Same technique as in Levine *et al.* (2000) Financial development influences the speed of growth convergence rather than the steady state.
Benhabib and Spiegel (2000)	Indicators of financial development are correlated to both TFP growth and to the accumulation of physical and human capital. But the indicators that are strongly correlated with TFP growth differ from those boosting investment.
Rioja and Valev (2004a, 2004b)	The impact of financial development on growth may vary with the level of financial development and of income.
Loayza and Rancière (2005)	Evidence that a positive long-run relationship between financial intermediation and output growth can co-exist with a negative short-run relationship
Edison *et al.* (2002, 2004)	Use a wide variety of measures of international financial integration and of equity market liberalisation. Introduce an interaction variable: GDP*capital account liberalisation International financial integration does not, in general, accelerate economic growth after controlling for financial and institutional characteristics. But interaction variables are found to be significant.
Rajan and Zingales (1998)	Estimate measures of the financial dependence of industries (*i.e.,* a reliance on financing from outside) and interact this measure with measures of financial development There is a significant and sizeable causal effect from the state of financial markets to economic growth.
Demirguc-Kunt and Maksimovic (1998)	In countries with better financial development, relatively more firms grow faster than predicted by internal accounting data.
Beck *et al. (*2004)	Financial development exerts a positive growth effect on industries that are technologically more dependent on small firms.
Becker and Sivadasan (2006)	Financial development may mitigate financial constraints of firms and enhance investment.

Source: OECD Secretariat.

respect to growth. Moreover, while until the last decade data were not easily available, today many organisations have undertaken (IMF, World Bank) or in the process of undertaking (OECD) projects to construct databases on financial policy indicators. Similarly, the importance of financial liberalisation for living standards and economic growth has encouraged independent organisations (such as the Heritage Foundation) to build their own policy indicators.

Outcome indicators describe the depth, the efficiency and the concentration of domestic financial markets, and the degree of financial liberalisation. The Fraser Institute has constructed an index that measures the freedom to exchange with foreigners called Economic Freedom of the World. With regard to the domestic financial market, Beck *et al.* (2007) construct perhaps the most comprehensive data set of indicators that measure the size, activity and efficiency of financial intermediaries and markets (some of these indicators are, for example, financial market capitalisation, bank concentration, net interest rate margin, credit and bank deposits and other measures of financial depth). With regards to international finance, outcome indicators often follow the same methodology of trade outcome indicators. Examples of these indicators are: the financial liberation indicator (overall stock of external liabilities and assets to GDP) and the financial freedom indicator (the share of portfolio equity and FDI to GDP, and the share of equity liabilities in total liabilities).[12] Data on the variables used to calculate the indicators are from official sources (IMF, World Bank) and are available for a large time span and very broad set of countries. Moreover, the indicators seem to matter for living standards. In fact, they are positively and significantly associated with GDP, both across countries and over time (Figure 7).

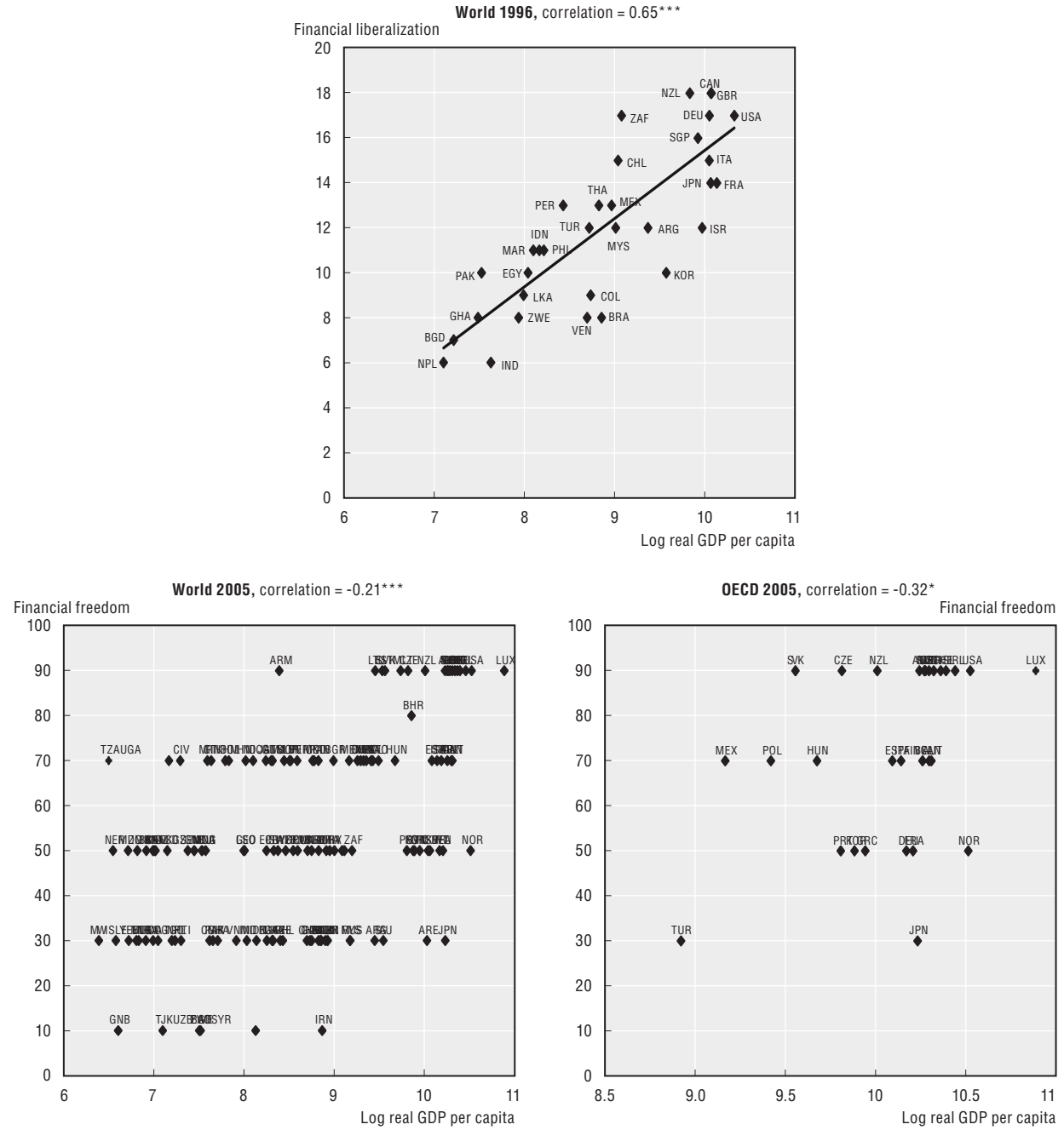
While all these indicators are easy to measure and can be used to assess the implication of the financial structure and liberalisation on growth, their main drawback is the presence of endogeneity problems with respect to growth. Thus, their use to assess the impact of financial markets on growth has to be considered jointly with the use of policy indicators (as instruments).

2.8. Reform and composite indicators

Measuring progress in structural reforms is crucial to formulate policy recommendations. Information on individual reforms is currently collected by the European Commission in its MICREF database for EU countries. These data often come from other international organisations or one-off studies. Indicators of reform intensity have been constructed as the average of labour (or product) market institutions for OECD countries (Høj *et al.*, 2006). There have been some interesting attempts to construct summary measures of reform progress by aggregating variables in different areas (Lora and Panizza, 2002; Eicher and Röhn, 2007). These indicators suffer from the drawbacks associated with composite indicators, in particular, the difficulty of interpreting them and the arbitrariness of the chosen weights. It also remains to be seen whether these indicators could be updated at a sufficient frequency to allow a regular monitoring of progress.

Among the composite indicators that cover a large number of areas, it is worth mentioning the Global Competitiveness Index from the World Economic Forum, which takes into account both macroeconomic and microeconomic foundations of competitiveness. Its scope is very large in terms of areas covered and country coverage. The indicator is a weighted average of indicators gathered in 12 pillars.[13] Weights of the different pillars depend on the country's level of development, but robustness checks suggest that the index is not sensitive to the weights. This indicator is regularly updated.

Figure 7. **Correlation between selected indicators of financial developments and GDP per capita**



Note: ***, ** and * denote significance at 1, 5 and 10%.
Sources: World Bank, IMF.

However, regular changes in the methodology (in terms of data source or composition of the index)[14] cast doubts on its comparability over time.

3. Conclusion

The analysis undertaken in this paper has identified a number of areas that matter for living standards, but are currently not well captured by existing indicators. Although

numerous indicators in these areas are currently available, there is still a clear need for the development of new policy indicators. Governance is clearly a domain that matters for living standards, but is currently absent in the framework. However, existing good governance measures are mostly perception-based and cannot be credibly used for policy recommendations. Further work will be required to develop fact-based indicators in several dimensions of governance. It will be particularly helpful to construct an indicator of property rights and continue to work on developing indicators of government management systems.

Depending on their use, the question of the regular update of these indicators can also be vital. Most of the structural indicators are, however, usually developed in the context of a one-off study and/or are not updated at regular intervals. This prevents their use in empirical work where time series are needed or in a surveillance process where reform progress is closely monitored.

Notes

1. Legal corruption is corruption that is undertaken within the legal framework.
2. It could be argued, nonetheless, that only a part of these two dimensions is purely policy-driven.
3. See, for example, Berger and Messer (2002), Self and Grabowski (2003), Soares *et al.* (2007), Joumard *et al.* (2008).
4. See Joumard *et al.* (2008).
5. See Bloom *et al.* (2004) and Jamison *et al.* (2005) for a review of studies assessing the impact of health on economic growth.
6. In particular, it can be argued that the additional information used to derive the new indicator cannot be easily assigned to EPL sub-indicators.
7. The regulator specifies a price basket that can increase in line with an exogenous measure of input costs minus measures of efficiency gains.
8. In particular, Wacziarg (2001) considers six channels through which trade affects growth: *1)* macroeconomic policy quality, *2)* government size, *3)* price distortions from the existence of black market premium, *4)* investment share of GDP, *5)* technology, and *6)* foreign direct investment. His results show that the most important channel is investment, accounting for 63% of trade's total effect on growth, while the technology channel and the stabilising channel account for the rest of the effect. For other empirical results see Lewer and Van den Berg (2003), which presents a critical survey of the literature on this topic.
9. Existing standards or regulations regarding safety or environmental issues are another form of non-tariff barriers. These barriers may be more stringent for developed countries than more traditional forms of non-barriers.
10. The authors used the following sources to determine scores for trade policy, in order of priority: World Bank, *World Development Indicators 2007* and *Data on Trade and Import Barriers: Trends in Average Tariff for Developing and Industrial Countries 1981-2005*; World Trade Organization, *Trade Policy Reviews*, 1995-2007; Office of the US Trade Representative, *2007 National Trade Estimate Report on Foreign Trade Barriers*; World Bank, *Doing Business 2008*; US Department of Commerce, *Country Commercial Guide*, 2004-2007; Economist Intelligence Unit, *Country Report*, *Country Profile*, and *Country Commerce*, 2004-2007; and official government publications of each country.
11. The indicator has a strong and positive relation both over time and cross country with GDP per capita. It is important to stress, however, that cross-country variation is the most important source of variability.
12. See Lane and Milessi-Ferretti (2007).
13. Institutions, macroeconomy, health, primary education, higher education and training, goods market efficiency, labour market efficiency, financial market sophistication, technological readiness, market size, business sophistication and innovation.
14. For instance, the exchange rate has been recently removed from the index.

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Migration and Labour Market Outcomes in OECD Countries

by
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Immigration pressures are increasing in most OECD countries. This article investigates the consequences of immigration for natives' labour market outcomes, as well as issues linked to immigrants' integration in the host country labour market. Changes in the share of immigrants in the labour force may have a distributive impact on natives' wages, and a temporary impact on unemployment. However, labour market integration of immigrants (as well as integration of second-generation immigrants both in terms of educational attainments and of labour market outcomes) remains the main challenge facing host economies. In both cases, product and labour market policies have a significant role to play in easing the economy's adjustment to immigration.

JEL Classification: E24, J31, J61, J68, L43.

Keywords: immigration, integration, employment, wages, labour market policy.

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Patterns of international migration have changed substantially in recent years. Immigration pressures are increasing in most OECD countries, with some countries experiencing unprecedented waves of immigration and others tightening their entry policies. In a number of countries, the nature of immigration itself has changed markedly, be it in terms of motivation, expected duration of stay or legality. Migration flows are likely to continue at a sustained pace in the coming decades, due to widening demographic imbalances between developing and OECD countries, coupled with diminishing transport and information costs, in the context of persistent income disparities across regions.

As one of the main channels of interdependency among economies, immigration is a longstanding concern for policy makers, and has been alternately considered as a challenge or an opportunity for the host economy, with multi-faceted consequences. Special chapters devoted to immigration in 11 *OECD Economic Surveys* shed light on a number of these issues. Two topics emerged as first-order priorities in the context of OECD economies:[1]

- The increasing share of immigrants in the labour force, especially of unskilled individuals, raises concerns about the consequences for labour market outcomes of natives.
- The labour market integration of immigrants is problematic in comparison to natives in numerous OECD countries, as illustrated by either lower wages or lower employment rates. In a longer-term perspective, the question of integration does not only concern immigrants, but also their children, the so-called "second-generation immigrants", in particular through their educational attainments and labour market outcomes.

This paper looks at both these issues, providing a summary of recent findings as well as new empirical evidence.

Once the trends and issues underlying the focus of this paper have been illustrated ("Migration trends and issues"), we then focus on the labour market impact of immigration. The available evidence is surveyed, and a new empirical analysis of the unemployment impact of immigration (and its link with product and labour-market policies) is proposed. The labour market integration of immigrants is investigated under the heading "Second-generation immigrants". The empirical analysis studies integration outcomes across a number of OECD countries and relates them to labour market policies.

Migration trends and issues

OECD (2006a) estimates gross inflows of long-term immigrants in 17 OECD countries at nearly 2.6 million people in 2004 (0.32% of their total population).[2] Migration backgrounds and policies are diverse (see Box 1) but net immigration flows contribute significantly to population growth in most OECD countries, in many cases overtaking natural population increases in recent years. Around 2000, the stock of immigrants amounted to 84 million in OECD countries (including almost 35 million in the United States), representing approximately 7.5% of the total OECD population.

Box 1. **Migration backgrounds in OECD countries**

Although this classification is neither exhaustive nor exclusive, four main groups of countries are usually distinguished in the OECD, based on their migration background (*e.g.* Bauer *et al.*, 2000; or OECD, 2006b):

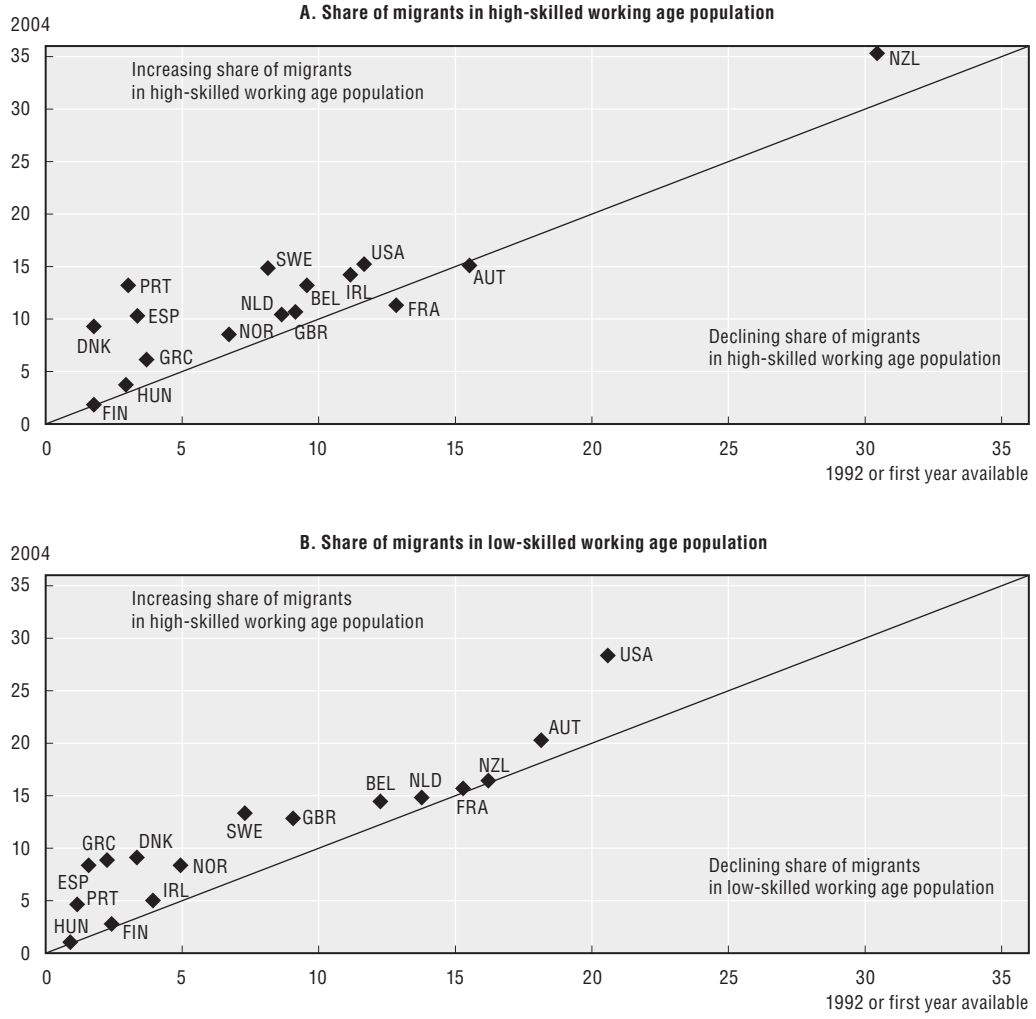
- Traditional settlement countries (Australia, Canada, New Zealand and the United States) are nations essentially built as a result of immigration, and continue to admit significant numbers of newcomers for permanent residence. While Australia, Canada, and New Zealand carry out selective migration policies, the United States' immigration is essentially family-based.
- European states with post-war labour recruitment (Austria, Denmark, Germany, Luxembourg, Norway, Sweden and Switzerland) experienced significant immigration flows in the 1960s and 1970s when they actively recruited foreign workers to compensate for labour shortages. Their "guest worker" programmes were based on the idea that immigrants would stay only temporarily in the host country. This did not prove to be the case for most of them, and these countries today have sizeable immigrant populations. Within this group, the Nordic countries have been putting stronger emphasis on humanitarian immigration since the 1970s.
- In other Northern European states (Belgium, France, the Netherlands and the United Kingdom), most immigrants (in the 1960s and the 1970s, in particular) came from former colonies. As such, they often already spoke the host country's language.
- New immigration countries (Ireland, Italy, Greece, Portugal and Spain) have only recently begun to experience net inflows of migrants. Although numerical limitations have been set to the number of labour market immigrants allowed every year into Greece, Italy and Spain, this policy is difficult to put into practice: most immigrants entered illegally (or, most often, overstayed their tourist visas), although many have become legal workers after regularisation processes, which have been relatively frequent and wide-ranging in these countries.

The composition of these international migration flows has changed considerably in the past decades, notably in terms of country of origin, demographic characteristics and motivation. The 1980s and 1990s were notably characterised by the diversification of host and sending countries, spurred by political events like the end of communism in Central and Eastern Europe and the former Soviet Union, and the opening up of China. The 1990s also witnessed a surge in flows of asylum seekers and refugees as a result of several regional conflicts (in particular in former Yugoslavia).

From an economic point of view, the skill composition of migration flows is of particular relevance. A significant trend over the past decade, common to most OECD countries, is the increasing share of tertiary-educated immigrants; their share among active immigrants who arrived over the previous ten years increased by more than ten percentage points in France, Ireland, Belgium and Luxembourg, and doubled in the United Kingdom (from 25 to 50%). As a result, the share of immigrants in the high-skilled working-age population was higher in 2004 than in the early 1990s in most OECD countries (Figure 1, Panel A). In several OECD countries, the share of tertiary-educated is now higher among recent immigrants participating in the labour market than among natives.

Figure 1. **Share of migrants in high and low-skilled working age population**

Share of migrants in high and low-skilled working age population



Note: Working age population is defined as people aged 16-64. The x axis refers to year 1992 except for Austria 1995, Finland 1996, France 1993, Hungary 1997, Netherlands 1996, Norway 1996, Sweden 1995, New Zealand 1997, United States 1994.

Source: Secretariat calculations based on European Union Labour Force Survey; US Current Population Survey; NZ Income Survey, Household Labour Force Survey.

In parallel, a large and frequently growing share of immigrants is unskilled. In Southern Europe, recent migration flows have been dominated by immigrants attracted by favourable employment opportunities in low-skilled occupations, in particular in agriculture (Spain), construction (Portugal, Greece, Spain) or small-size manufacturing firms (Italy). In these countries previous waves of immigrant tended to be smaller but more heavily focused on higher-skilled migrants. A similar finding is valid for Germany, where ethnic German migrants make up the bulk of the recently-arrived foreign born; while the early waves of ethnic Germans were rather skilled, more recent ones have tended to be less qualified and also less proficient in German. In France, the share of low-skilled workers among recent immigrants is also high. In the United States, the question of the decline in

the "quality" of new immigrants has been the subject of strong debate, fuelled by evidence showing the decline in the earnings of immigrants, compared with natives.[3] As a consequence of this high and often-increasing representation of unskilled among immigrants, the share of immigrants in the unskilled working-age population increased in most OECD countries during the past decade, sometimes substantially (as in the United States, in particular – see Figure 1, Panel B).

In many OECD countries, the distribution of educational attainments among immigrants has thus been increasingly U-shaped, with an over-representation of both highly-skilled and unskilled persons. While the former reflects the increasing mobility of high-skilled workers (generally facilitated or encouraged by migration policies), the latter is driven by both economic and family reunification motives, and it is the main cause for concerns on labour market outcomes among natives, a topic addressed below under the heading "The labour market impact of immigration". The significant inflows of unskilled workers also explain why labour market integration of immigrants is increasingly seen as a challenge in numerous OECD countries. Integration *per se* is an important objective, but the stakes are broader: while the fiscal impact of immigration appears to be generally small and often positive in OECD countries, recent studies suggest that it depends crucially on the labour market integration of immigrants; when immigrants fail to integrate, the cost for public finances may be large, in particular in countries where unemployment and welfare benefits are generous (Box 2).

Box 2. **The fiscal impact of immigration**

Beyond the short-run fiscal impact of immigrants, resulting from the difference between migrants' tax payments and related public spending, a more comprehensive approach would assess the net present value of the fiscal impact of immigrants over their entire lifetime (possibly including the fiscal impact of future descendants). This latter approach requires anticipating future developments, a questionable exercise by nature. While the present structure by age at immigration matters in the short-term, the fiscal impact of immigration in the long term depends on the age of arrival in the host country. The net present value of the lifetime fiscal impact of immigrants is likely to be greatest for those arriving in the first half of their working life (when their initial education no longer needs to be financed, but most of their social contributions are still to come), in particular, if they are near their peak wage (so that their peak contributions are not too strongly discounted). The skill level of immigrants also matters, since it conditions their labour market outcomes (participation, unemployment, wages), as well as their reliance on social benefits.

The possible contribution of immigration to the financing of pension systems has been specifically debated. In a long term perspective, the consequences of immigration for the viability of "pay-as-you-go" pension schemes depend upon the actuarial profile of the system. Even though the transitory effects of immigration may last for a significant period (positive, temporary impacts on the financing of the "pay-as-you-go" pension system are mentioned in OECD Economic Surveys for Czech Republic, Spain and Greece), these effects are likely to remain limited. Migration flows required to address demographic imbalances that make many pension systems unsustainable would be unrealistically large (see also United Nations, 2000; Holzmann, 2005).

Box 2. **The fiscal impact of immigration** *(cont.)*

While numerous studies (many of them surveyed in the OECD Economic Surveys) find that the net short-run impact of the average immigrant on budget balances is small and often positive, significant cross-country differences emerge. From a review of estimates for different countries, Coleman and Rowthorn (2004) conclude that the annual fiscal impact of the stock of immigrants is usually below +/– 0.5% of GDP. The balance seems clearly positive (although low) in settlement countries, where immigrants tend to be more skilled and enjoy higher employment rates than natives (see *e.g.* Ablett, 1999 and Access Economics, 2002, on Australia; Akbari, 1995 on Canada). In recent immigration countries, the short-term impact of immigration is also found to be positive, due to the overrepresentation of persons of working age among immigrants and to their relative high employment rates (see *e.g.* Aparicio and Tornos, 2000, for Spain and Giovanni *et al.,* 2004, for Italy). The long-term impact has also been estimated to be positive, but such assessments are necessarily tentative where mass immigration is recent (see Moscarola, 2001, for Italy and Collado *et al.,* 2004, for Spain). For the United States, Storesletten (2000) estimates a positive net present value for the average current immigrant over his/her lifetime, whereas Auerbach and Oreopoulus (2000) estimate a range of balances from positive to negative, depending on underlying assumptions (regarding, in particular, defence expenditures and how the fiscal burden is shared across generations). In Northern European countries, however, immigrants (in particular those from developing countries) are estimated to generate significant fiscal costs (see Roodenburg *et al.,* 2003, for the Netherlands; Pederson, 2002 and Schou, 2005, for Denmark and Storesletten, 2003, for Sweden; for Germany, however, Bonin *et al.* (2000) estimate the fiscal impact of immigration to be positive).

Different demographic structures of immigration explain part of these cross-country differences, given the sharp heterogeneity of the fiscal impacts across individuals. For the United States, for instance, Storesletten (2000) estimates that an infant immigrant would cost public finances almost four times annual GNP per capita, conditional on being low-skilled during his/her entire life, while a 40-44-year-old high-skilled immigrant would yield a gain worth seven times annual GNP per capita.

But the key driver of these different fiscal impacts is an immigrant's integration into the host labour market. This is especially true in countries with generous welfare and unemployment benefits. In Sweden, a one percentage point increase in immigrants' participation rate is estimated to raise the average net present value of an immigrant's lifetime fiscal contribution by 14% of annual GNP per capita (Storesletten, 2003). The weak labour force participation among immigrants in Northern Europe is thus the main factor driving the estimated negative fiscal impact of immigration: immigrants from developing countries often exhibit employment rates 10 to 20 percentage points lower than those of natives. This raises concerns not only about the current fiscal burden but also about its future evolution if immigrants' integration does not improve.

The labour market impact of immigration

Do immigrants "take jobs away" from native workers in OECD countries, or lower their wages? Despite the numerous attempts to address this question, the answer remains controversial. Not only does the assessment for single countries vary widely (as exemplified by the US case), but also labour market adjustment to immigration seems to differ across countries, thus raising questions about the role of country-specific factors,

such as product and labour market policy settings, in shaping the labour market impact of immigration. This section discusses the existing literature on the impact of immigration on wages, and presents the results of new OECD estimates on the unemployment impact of immigration in a dynamic context (presented in detail in Jean and Jiménez, 2007), with an emphasis on the role of structural policies.

How and why should immigration influence the labour market?

Textbook models suggest that the first order effect of immigration is to lower real wages in the economy, to the extent that the labour demand curve is downward-sloping. This generates a welfare gain for natives, as well as distributional consequences with native workers' losses more than balanced by capital owners' income gains (see *e.g.* Borjas, 1999). If for a variety of reasons there are barriers to the downward adjustment of wages, immigration may result instead in higher unemployment. Wage adjustment should finally occur, however, except in the case where it is hampered by a legally binding minimum wage.

Higher returns to capital stimulate investment and firm creation. In the medium term, this leads to capital per worker and the number of firms to adjust. Wages (and/or unemployment) and the return to capital should then return to their original levels. If immigration flows are anticipated by economic agents (for instance, because they are stable over time) or if the capital stock brought by the average immigrant is close to that of the average native (which is not usually the case), the capital/labour ratio may not change in the first place or may return very rapidly to its original level.

Additional welfare gains may stem from skill-mix differences between immigrants and natives, by allowing complementarities between workers to be exploited. In a small open economy context, the Rybczynski theorem states that immigration should influence the trade specialisation of the economy, not relative factor prices. Other than across US states, however, available evidence suggests that such an effect accounts for only a small part of the adjustment at the country level (Hanson and Slaughter, 1999; Gandal *et al.*, 2004). In practice, the differences in skills between immigrants and natives influence relative wages among workers in the host economy. The magnitude of the impact on relative wages depends on the changes in the relative supply of different categories of workers, and on the degree of substitutability among them. If relative wages do not adjust, immigration may also influence the distribution of unemployment rates by skill category.

A number of factors make the impact of immigration even more complex. Because immigrants may differ from natives by their behaviour, their presence potentially "greases the wheels" of the labour market: their more responsive location choices help arbitrate away differences in economic opportunities across geographic areas, thus improving global labour market efficiency, as reflected in lower equilibrium unemployment (Borjas, 2001); their often lower reservation wage[4] in many cases helps accommodate labour force shortages in specific occupations (see *e.g. OECD Economic Surveys* on the Czech Republic, Greece or Spain). More generally, it cannot be excluded that immigrants influence the equilibrium rate of unemployment, since their specificities in terms of characteristics and behaviour may influence wage setting mechanisms (as a result, for instance, of their different reservation wage or skill mix *vis-à-vis* those of natives), as well as price-setting mechanisms (at least during the transition period following an immigration shock). Finally, immigrants may generate externalities, in particular when they are highly skilled. For

these reasons, the size of the labour market impact of immigration and its persistence remains to a large extent an empirical issue.

Available evidence

Almost all studies of the labour market impact of immigration are country-specific. The results reviewed in the *OECD Economic Surveys* do not allow general and clear-cut conclusions to be drawn, partly because approaches differ across studies.[5]

The traditional approach to measuring the impact of immigration on local labour markets, pioneered by Grossman (1982), has exploited the spatial dimension of the data. It assesses whether relative labour market developments across geographical areas are linked to relative changes in immigration (measured, for instance, by the share of immigrants in the labour force). Following this approach, a large number of papers (many of them focused on the United States) have found a small and often insignificant effect of immigration on labour market outcomes. This is attested by meta analyses:[6] Longhi *et al.* (2005) report that across a number of studies using this cross-regional approach, the average estimated impact of a one percentage point increase in the share of immigrants in the labour force is to lower wages by only 0.12%, while Longhi *et al.* (2006) calculate that the average estimated impact on natives' employment is a negligible –0.02%. The estimated negative impact tends to be larger in European countries than in the United States (–0.03% on average across studies, compared with less than –0.01%), larger on earlier immigrants than on natives (–0.05% *vs.* –0.02%), and stronger on low-skilled than on high-skilled workers (–0.04% for low-skilled only). The impact is also weaker on average when estimated for small geographical areas rather than for larger ones. No differential impact across gender is found for wages, but the average estimated impact on employment is more negative for female than for male workers.

Statistical inferences based on differences across geographical areas face two major methodological hurdles. *First*, immigration is endogenous to wages and employment, because new immigrants are attracted by thriving labour markets. This positive impact of wages or employment on immigration may bias towards zero the estimated impact of immigration on wages or employment. The meta analysis by Longhi *et al.* (2006) indeed concludes that those studies attempting to correct endogeneity in employment equations (using an instrumental variables approach) find a larger negative impact than those that do not. *Second*, natives may respond to competition from immigrants by moving their labour force or capital to other areas, until returns to capital and labour are again equalised across areas. In this case, an inter-regional comparison of labour market outcomes may not accurately show the impact of immigration, which would be diluted throughout a larger area.

Borjas (2003a) overcame these two obstacles by basing the assessment on the comparison across labour market segments, defined by levels of education and experience at the country-wide level. This approach ensures that estimates are not biased by endogeneity, as long as cross-segment differences in immigration flows are not driven by cross-segment differences in wage growth. This assumption seems appropriate if we consider that most immigrants have beforehand only approximate information about the detailed (by education and experience level) labour market conditions of their country of destination, even if they know which geographic areas enjoy favourable business cycle conditions;[7] and even when informed precisely, immigrants are likely to choose their destination based on cross-country relative wages rather than cross-segment relative

wages. Borjas finds robust evidence of a downward impact of immigration on wages of natives with similar characteristics. He estimates that a 1% increase in labour supply in a given labour market segment reduces wages by 0.3 to 0.4%, an impact substantially higher than found in earlier empirical studies. Applying the same method to Mexico and Canada delivers similar results (Aydemir and Borjas, 2005).[8] Borjas (2005) shows, in addition, that at the sub-national geographical level (census division, state or metropolitan area), higher foreign immigration in one area consistently results in lower immigration of natives from other areas, and in higher emigration of natives towards another area in the United States. By varying the geographical level of analysis, he confirms that these movements by natives attenuate significantly the impact of immigration, by an estimated 40% at the state level, and 60% at the metropolitan area level. Although challenged by Card (2005) based on indirect evidence,[9] these findings constitute a consistent and robust assessment of the impact of immigration on wages in North America.

However, Borjas' estimates only reflect a short-term impact, since it is assumed that the capital stock remains constant. Moreover, as noted by Ottaviano and Peri (2005), Borjas' results concern specifically the impact of immigration of workers with given education and experience on the relative wages of natives with similar characteristics. This specific impact may differ substantially from that on average wages: immigrants are in close competition (*i.e.* highly substitutable) with natives of comparable education and experience, but competition with natives differing more by their personal characteristics is less direct. Assuming an endogenous adjustment of the capital stock (*i.e.* implicitly, in the medium term), they find that complementarity effects dominate at the aggregate level and estimate that immigration generates "a large positive effect on the average wages of US-born workers". In the United States, immigration thus seems to have a significant negative impact on relative wages in the short-term, at the expense of natives most in competition with immigrants, but possibly a positive effect on average in the medium term.

Macroeconomic studies of the impact on employment are scarcer than those on wages. Skill-level approaches applied to Germany (Bonin, 2005) and to Spain (Carrasco *et al.,* 2006) did not identify any significant impact on natives' employment. Among case studies of immigration shocks, cross-regional approaches have generally been preferred (see in particular Altonji and Card, 1991; Hunt, 1992; and Carrington and Lima, 1996). Cohen-Goldner and Paserman (2004) is an exception, however, since it studies the massive migration from the former Soviet Union to Israel in the 1990s (representing an 18% increase in Israel's population in a decade) through a skill-level approach. The authors find a significant effect on wages, vanishing after four to seven years, but no effect on employment. Hercowitz and Yashiv (2002) study the same migration episode based on quarterly, macro-economic data. Given the political source of this migration episode, endogeneity of labour market outcomes is unlikely to blur estimates in this case. They emphasise the dynamic pattern of the impact, arguing that immigrants integrate more quickly into the product market than the labour market, thus quickly boosting labour demand, but labour supply only progressively so. Their estimates, based on simultaneous equations of native employment and of the relative price of domestic goods, confirm this prior. They point to a sizeable and significant negative impact of immigration on natives' employment, though delayed and temporary. Beyond the usual question of the permanent impact of immigration, these results suggest that the (un)employment impact of immigration may well be transitory.

The role of policies on the product and labour market

All these studies suggest that immigration may well have an impact on natives' (un)employment, at least in some cases, but results vary widely across countries and approaches. Beyond differences linked to methodological choices, cross-country differences in policy settings are likely to result in different adjustments to immigration. It is striking, for instance, that virtually no employment effect is found in the United States, while the same is not true in Europe; conversely, the impact on relative wages seems to be higher in the United States than in European countries.

Angrist and Kugler (2003) have investigated how policies may influence the labour market impact of immigration within the European Union. They argue, based on a stylised model, that "institutions such as firing costs, high replacement rates, rigid wages and business entry costs may ultimately aggravate the negative impact of immigration on equilibrium native employment". They study the long-term impact of the stock of immigrants on equilibrium unemployment among natives and find some empirical evidence that institutions do matter (entry barriers in particular), although the results are often insignificant, in particular when country-specific time trends are included.

Because immigration is a labour supply shock, any policy that modifies the slope of the labour demand and supply curves (or of the wage- and price-setting schedules) may change its impact on labour market outcomes. Under imperfect labour market adjustment, a policy change that increases the responsiveness of wages to unemployment (*e.g.* a reduction in the average replacement rate) can, for instance, lower the unemployment impact of immigration. Higher wage responsiveness of labour demand (as would result from increased competition in product markets) is also likely to limit the impact on unemployment.

The influence of policy is also linked to the differences between immigrants and natives, both in terms of their personal characteristics and behaviour. Because many immigrants arrive from less-developed countries, their human capital and productivity level are often lower than those of natives. In those cases, immigrants are likely to be priced out of the market by excessively high minimum wages. Moreover, and except in specific cases such as employer-nominated immigration, immigrants are not incumbent in the labour market upon arrival in the host country, and they subsequently remain overrepresented among outsiders, at least for several years (see below). As such, they are unlikely to benefit from employment protection legislation (EPL), at least during the first years following migration. To the extent that EPL protects incumbent workers (mainly natives) against competition from outsiders, including most immigrants, it should be expected to reduce the employment impact of immigration on natives, at least in the short run.

In a dynamic context, policies may affect the impact of immigration through different channels. For instance, strict EPL is likely to make the substitution of immigrant for native workers more costly during the first years following immigrants' entry (because of the firing costs associated to native incumbent workers), thus limiting the impact of immigration on native employment. However, at a later stage EPL may boost immigrant employment, precisely because they are less likely to be covered by the relevant legislation (since they are less likely to be already employed with a long-duration contract), making their overall labour cost comparatively lower. Similarly, immigrants are less likely to be eligible for unemployment benefits, at least during the initial years following immigration.

A higher replacement rate of unemployment benefit is, therefore, likely to widen the difference in reservation wages between natives and immigrants, thus potentially increasing the relative impact on native unemployment. In the longer run, however, this effect should vanish. In addition, given the role played by firm creation in labour market adjustments, it is likely that anti-competitive regulations would slow down the increase in immigrants' participation in the product market, thus potentially lengthening the unemployment impact of immigration.

Finally, as already mentioned, the different behaviour of immigrants may also help to "grease the wheels" of the labour market. By removing bottlenecks, the willingness of immigrants to accept jobs not filled by natives may foster growth and create other complementary jobs. Their higher responsiveness (for instance, in terms of location choices) may also result in improved resource allocation with positive aggregate income effects. Such impacts are closely linked to the policy setting, just as the usefulness of the "grease" depends upon the initial state of the "wheel".

A cross-country reassessment of the impact of immigration on unemployment

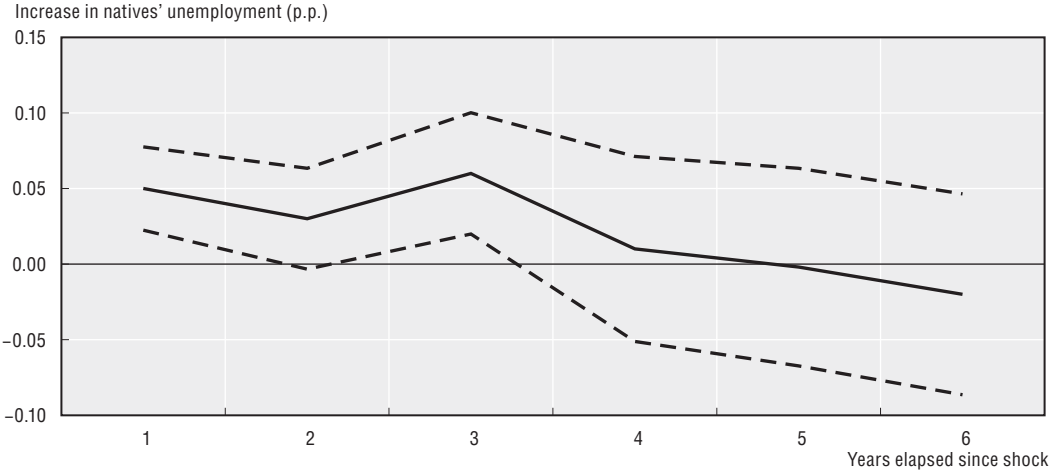
Existing studies thus suggest that the employment impact of immigration is relatively small, although three concerns surround this conclusion: many of these studies are based on cross-regional analyses, potentially biased by the migration-induced mobility of natives; most studies focus on the permanent impact of immigration, but do not investigate its transitory impact; and, except in one study, the role of policies is not accounted for.

These issues are jointly addressed in Jean and Jiménez (2007), where the empirical analysis across eighteen OECD countries exploits the international and skill level dimension of the data, accounting for the dynamic profile of the impact, and for the role of product and labour market policies.[10] The focus is on the impact of immigration on native males' unemployment.[11] A disaggregated level in which each national labour market is divided into eighteen segments (corresponding to six-year categories of experience[12] crossed by three levels of educational attainment) is used alongside an aggregate analysis. The time profile of the impact of immigration is estimated through an "impulse response" specification, including, separately, annual changes of immigration over the previous five years. The analysis is performed using Labour Force Survey data for the United States, New Zealand, Australia and fifteen European countries, over the period 1984-2003 for the aggregate analysis, and 1992-2003 for the disaggregated analysis.

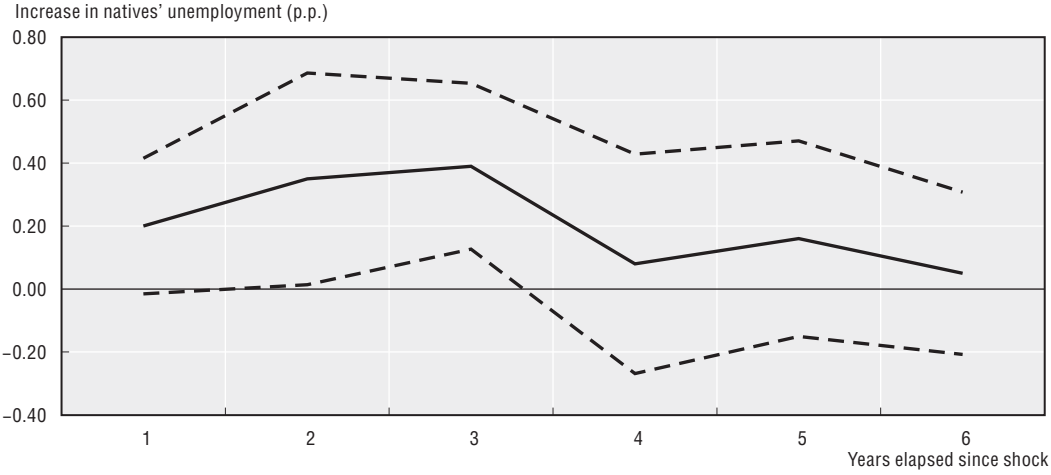
Only *changes* in immigration are found to have an influence on natives' unemployment, and their impact is temporary. The estimated impact is significant but very weak at the disaggregated level; it is more substantial at the aggregate level (Figure 2). In both cases, however, the impact of immigration on natives' unemployment is insignificant after three years: no significant, permanent impact of the *level* of the share of immigrants in the labour force is found on natives' unemployment. The estimated initial responses must be compounded by the persistence of unemployment shocks, measured through an auto-regressive term. This implies that the real impact on unemployment is felt after the initial three years, to an extent that depends crucially on the general persistence of unemployment shocks in the economy. Stronger results at the aggregate level presumably reflect the fact that immigrant workers do not only compete with native workers in the same segment. This is all the more true given the widespread over-qualification among immigrants (Dumont and Monso, 2007). After a few years, this

Figure 2. **Estimated direct impact of a permanent 1% increase in the share of immigrants in the labour force on natives' unemployment (with 95% confidence bands)**

Panel A. **Disaggregated impact (on one skill cell with respect to others)**



Panel B. **Aggregate impact**



Note: The following base specification is adopted for the disaggregated estimations:

$$U_{xdct} = \alpha + \lambda\, U_{xdc(t-1)} + \sum_{l=1}^{6} \beta_l \Delta I_{xdc(t-l)} + \beta_{LR}\, I_{xdc(t-6)} + \mathbf{D}\times\mathbf{X}\times\mathbf{C} + \mathbf{D}\times\mathbf{C}\times\mathbf{T} + \mathbf{X}\times\mathbf{C}\times\mathbf{T} + u_{xdct}$$

where U is the unemployment rate of natives, I is the share of immigrants in the labour force, **Pol** is a vector of product and labour market policies, u is an error term. Subscripts d, x, and c refer to educational attainment, experience, and country, respectively, and jointly define a labour market segment, whereas t refers to time. **D**, **X**, **C** and **T** represent fixed-effects for educational attainment, experience, country and time, respectively.

Source: Jiménez and Jean (2007), Figure 2.

stronger effect on aggregate may be compensated by the positive cross-segment effects mentioned above ("grease in the wheels", lower equilibrium unemployment, positive externalities), which are only accounted for in the aggregate analysis. It is also noteworthy that the aggregate impact is less and hardly significant during the first year. This tends to confirm Hercowitz and Yashiv's (2002) finding that the employment impact of immigration is delayed, presumably reflecting the progressive entry of immigrants into the labour market.

Including interactions with policy variables does not significantly modify the estimated direct impact of immigration at the disaggregated level. Interactions with product market regulation and the replacement rate of unemployment benefits are generally insignificant. However, EPL is found to influence the impact of immigration: it lowers this impact at first, reflecting a protective effect of EPL, whereas the impact is found to be increased in subsequent periods. Thus, the increase in the relative cost (and/or the slower adjustment to market conditions) of native workers *vis-à-vis* immigrants induced by higher EPL more than balances its initial protective effect.

A similar pattern is found for the interaction with EPL at the *aggregate level*: the protective role dominates in the first year following immigration changes (lowering the impact on unemployment), while firing costs strengthen the upward impact of immigration on unemployment in the medium-term. In line with Duval *et al.* (2007), these results suggest an ambiguous effect of EPL, whereby the initial dampening of the immigration shock provided by employment protection comes at the cost of higher persistence of the unemployment consequences of the shock in subsequent years.

A higher replacement rate of unemployment benefits, although insignificant in the first two years, is also found to increase the impact of immigration three to four years after entry. In both cases these effects likely reflect the relative increased cost of native labour implied by such policies.

At the aggregate level, however, the most robust interaction is found for product market regulation, which significantly magnifies the unemployment impact of immigration between one and five years after entry: the unemployment impact is thus both stronger and more durable when product market regulation creates a barrier to entry in (otherwise) competitive markets. The role of firm creation (and adjustment of product supply in general) does not show up at the disaggregated level, because it affects fairly equally all labour segments, but it is important at the aggregate level where costs and barriers to business start-ups impinge on immigrants' employment. The estimated persistence of unemployment shocks is also found to be slightly higher under relatively stringent product market regulation.

Beyond these regression results, the influence of framework conditions can be put in a more general context. Hence, these findings are consistent with the empirically-based recommendations in the *OECD Jobs Strategy* (see *e.g.* Bassanini and Duval, 2006). Enhancing the adaptability of the labour and product markets to shocks should help limit their impact while bringing back quickly the labour market to a new equilibrium. Such logic should apply to immigration as well as to other types of shocks.

The role of selective migration policies

Migration policies may also play an important role in shaping the impact of immigration through their influence on immigrants' skill mix. In particular, increasing immigrants' average skill level may alleviate the concerns about the consequences of immigration for native, unskilled workers. The effects of these policies cannot be easily captured in empirical analysis, but scattered evidence (including from *OECD Economic Surveys*) provides useful clues.

Settlement countries other than the United States are an example in that respect, because they have been applying selective immigration policies for a significant period. In fact, they tend to have a higher proportion of their immigrant population with a tertiary

degree. In 2001, according to census data this was the case, for instance, in Canada and Australia, where 38% and 43% respectively of immigrants held a tertiary degree and 54% and 45% of resident PhD holders were born overseas. New Zealand is in a comparable situation. According to the *OECD Economic Surveys*, the emphasis on skilled immigration has been successful in delivering positive fiscal and labour market outcomes, with immigrants integrating rapidly in host economies.

However, there are limits to selective immigration policies (OECD, 2006a). In the first place, countries are constrained by multilateral commitments (*e.g.* areas with free movement of labour; multinational staff mobility) and humanitarian commitments (including family reunion). Moreover, in many countries, illegal immigration accounts for a significant share of inflows. Host countries therefore often have little discretionary control over flows of the corresponding categories of migration, which can be substantial. For instance, according to OECD (2006a), in 2003 discretionary inflows accounted for as little as 26% of total inflows of permanent legal immigrants in Italy, 17% in France, 6% in Switzerland and 5% in Sweden. Countries where non-discretionary immigration flows account for the bulk of immigration are not in a position to apply any selection to a significant part of their immigration, unless they choose to increase substantially the number of immigrants accepted. In any case, carrying out a selective migration policy does not mean fully controlling for migrants' skills: in Australia, Canada and New Zealand, selection only applies directly to 20 to 25% of the inflow of permanent legal immigrants, and to approximately half the inflow when accompanying family members (who also tend to have relatively high skill levels) are taken into account, in addition to principal applicants. Besides, immigration policies have no direct control over re-emigration.

Secondly, the management of effective selective migration policies is costly; it implies putting in place effective budgetary planning and management, as well as complex administrative structures (see Liebig, 2007b, on Australia). The identification of appropriate selection criteria and the assessment of candidates are not necessarily easy tasks and, in some cases, have not met with expected outcomes. In recent years, selection systems in settlement countries have tended to evolve from stressing job- or sector-specific skills to requiring more global skills, especially language skills which make workers adaptable to different areas or sectors. There is also a tendency to use more temporary permits (*vis-à-vis* permanent permits provided in the traditional system), in part to address temporary labour shortages, but also to allow for some on-the-spot selection of those workers who integrate better in the local labour market before providing them with a settlement permit. *OECD Economic Surveys* recommended pursuing this adaptation as it adds flexibility to the selection process and to local labour markets.[13]

Selective policies are not the only way to influence the skill-mix of immigration; relying on employers to identify the workers and requisite skills is another possibility. Immigrants selected by employers on the basis of their short-term needs may not have the required skills to integrate the labour market in the long-run.[14] However, such a policy may lead to highly-skilled immigration when local policies and framework conditions tend to render the country especially attractive for skilled workers, as illustrated by the cases of the United Kingdom, Ireland and, to some extent, the United States.

Numerical limitations are another way to influence the size and composition of immigration flows. In countries under review where they were in place, the *OECD Economic Surveys* considered that such limitations were often inflexible and failed to meet the real

needs of local labour markets. The definition and implementation of numerical limitations seem to be slow, costly and relatively rigid. The OECD recommended that job-, geographic- or sector-specific work permits or numerical limitations be avoided. If selection is pursued, governments should rather favour broad skills and abilities, with immigrants self-selecting themselves in the most appropriate areas of local labour markets.

Labour market integration of immigrants

This section focuses on immigrants' labour market integration, narrowly defined as convergence of migrants' wages or (un)employment rates towards those of natives. Although integration encompasses a variety of social and cultural aspects, its labour market dimension is of special importance because it largely conditions other aspects of integration and is a key determinant of its broader economic consequences.

Evidence on labour market integration

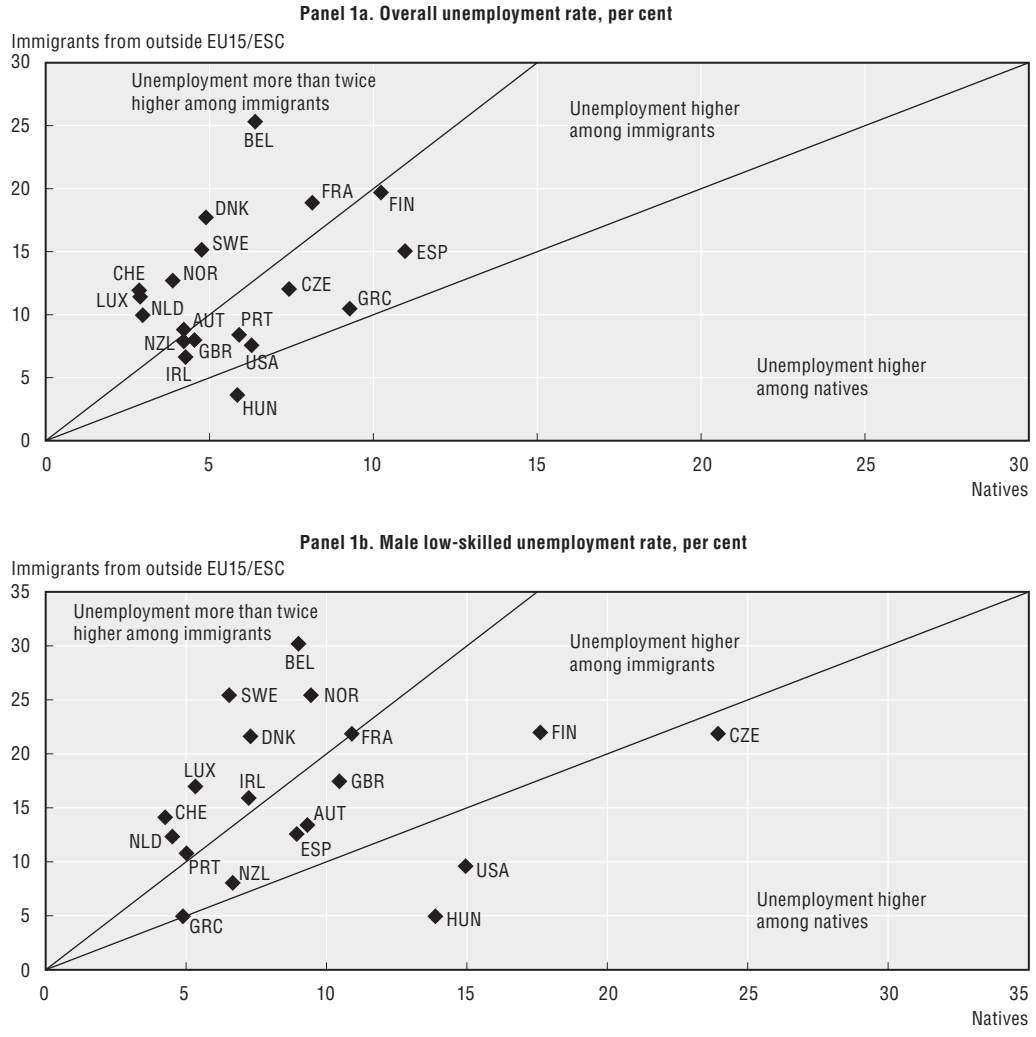
As illustrated in Figure 3 (Panel A), the unemployment rate among immigrants is higher than among natives in virtually all OECD countries.[15] The difference is sizeable in most cases, and immigrants' unemployment rates are more than twice as high as those for natives in several countries.

The crude preliminary evidence given in Figure 3 (Panel B) suggests that differences from natives in terms of personal characteristics (*e.g.* education, age, gender, experience, and sector of activity) are not the only explanation for these gaps: when computed for low-educated males only, unemployment rates are still significantly higher among immigrants than natives. Following the analytical framework developed in Chiswick (1978), it is common practice to control for a wider range of different observable characteristics at the individual level when comparing the labour market outcomes of immigrants and natives. The usual procedure is to estimate separately for males and females an equation modelling labour market outcomes (wage, probability of either being active or employed) at the individual level as a function of, *inter alia*, marital status, educational attainment, labour market experience, area of residence and sector of activity, as well as immigrant-specific variables such as immigration status (possibly by region of origin), duration of stay in the country, language spoken at home, *etc*. The impact of these migrant-specific variables indicates to what extent being an immigrant influences individual labour market outcomes.

Studies using this approach have provided abundant evidence that in many OECD countries immigrants display *ceteris paribus* less favourable labour market outcomes than natives. Most of these studies focus on a single country and cover wages and/or (un)employment probabilities. Wage differences in the United States have been the object of numerous in-depth analyses; a number of studies have also been devoted to other settlement countries, notably Canada and Australia.[16] Comparisons for European countries are fewer.[17] The main findings can be summarised as follows:

- Immigrants on arrival in a new country face a number of handicaps and constraints, notably related to language proficiency, cultural and social norms, social capital, quality of education, skills transferability and legal constraints.
- When compared with similar natives, immigrants generally face a significant earnings gap (for instance, the estimated wage difference in the United States averages –20% across different studies).[18]

Figure 3. **Unemployment among non-EU/non-English speaking immigrants and among natives in OECD countries, in 2003**



Note: Solid line: unemployment among immigrants equal to unemployment among natives. Dotted line: unemployment among immigrants twice as high as unemployment among natives. The figures only concern non-EU immigrants in European countries, and immigrants from non-English speaking countries in the United States and New Zealand.

Source: Secretariat calculations based on European Union Labour Force Survey; US Current Population Survey; NZ Income Survey, Household Labour Force Survey.

- Especially in European countries, immigrants generally exhibit a higher risk of unemployment than comparable natives. However, situations differ across countries. High relative unemployment rates in France (Meurs *et al.,* 2005), for instance, contrast with relatively quick employment integration of recently-arrived immigrants in Spain (Amuedo and de la Rica, 2006).[19]
- Because they have decided to migrate, immigrants – at least as far as economic migrants are concerned – are likely to represent a particularly motivated and ambitious part of the origin-country population (Chiswick, 1999). A further selection of immigrants results from the subsequent decision of some of them to migrate back to their country of origin ("return migration"). These selections can significantly affect immigrants' observed and unobserved characteristics.

- Immigrants' integration depends heavily on motivation and status. In particular, asylum seekers and refugees exhibit significantly lower employment rates than other immigrants even several years after immigration (see *e.g.* Liebig, 2007a; or Constant and Zimmermann, 2005). This may result from the fact that they represent a specific part of the origin-country population, from the trauma endured by some of them, or merely from different legal constraints.[20] The implicit difference in time horizons across migration categories also affects subsequent human capital investments and wage assimilation (Cortes, 2004).

One crucial dimension of immigrants' integration, which has been abundantly debated in the literature, concerns the dynamics of assimilation; in other words, the process by which immigrants' labour market outcomes converge toward those of natives. The main findings in that respect are the following:

- Assimilation involves the acquisition of human capital that is specific to the host country, notably language skills,[21] as well as the accumulation of "social capital", including the process of learning local norms and customs. Indeed, a number of non-economic factors (such as culture or networks) affect the extent and speed of assimilation.[22] Country of origin also matters, through culture, skills' transferability, as well as self-selection determinants (Borjas, 1987).
- Based on cross-section data, assimilation cannot be disentangled from differences in immigrants' unobservable characteristics across cohorts (the so-called "cohort effects"). Cohort effects have been found to be important for a number of countries, and most often have had a worsening impact on the quality of the immigrants' labour force over time.[23] Furthermore, these differences are not random; they are linked to the migration policy, as well as the wealth and inequality of the country of origin relative to the host country.
- Immigrants' wages tend to catch-up to those of natives over time, but do not necessarily equalise fully.
- To the extent that participation in the host country's labour market is a key factor of integration (Lemaître, 2007; Liebig, 2007a), assimilation may also vary across cohorts depending on the labour market conditions at the time of entry in the country (for a recent analysis on Sweden, see Aslund and Rooth, 2003). Times have changed in this respect. Immigrants in the 1950s and 1960s used to find a job easily and rapidly (in some cases through guest-worker programmes) in the context of labour shortages in labour-intensive industries; this has not been the case over the past two decades. Hence, labour market outcomes of immigrants who arrived long ago are likely to be overly optimistic predictors of future outcomes for more recent arrivals.

A striking feature emerging from available empirical studies of immigrants' integration is the wide disparity of estimates, not only across countries, but also for a given country. This is largely due to cross-study differences in terms of data, methodologies, and periods (cohorts) analysed. Such heterogeneity – and limited comparability – makes it difficult to draw general conclusions from country-specific econometric analyses. By contrast, cross-country studies based on harmonised data can help identify some of these determinants.

The role of policies entailing a specific treatment for immigrants

Despite their constraints and limitations, many aspects of migration policy may influence the labour market integration of immigrants. To the extent that migration policy affects the level of education of new immigrants, it may increase their employment probability and average wage.[24] Migration policy might also influence the nature of migration (in terms of motivation), which in turn bears consequences in terms of integration, as outlined above.

The economic situation of migrants may also be directly influenced by the host country's policies entailing a specific treatment for immigrants, reflecting either restrictions in migrants' rights or targeted measures:

- Migrants are frequently faced with restrictions in access to unemployment or welfare benefits or to the labour market (see *e.g.* Fix and Laglagaron, 2002). In many cases these restrictions have been prompted by the fear that generous welfare benefits would act as magnets to immigrants, thus attracting persons more likely to become benefit recipients (Borjas, 1999). Such restrictions may help to control public spending and also lower immigrants' reservation wages, thus accelerating their labour market integration. However, the importance of this "welfare magnet" effect has not been proved,[25] and the limited access to medical care may entail public health risks.[26] Economic pressure may also make job searching more difficult for immigrants, thereby fostering the development of illegal work and the risk of over-qualification.
- A number of OECD countries carry out specific policies to ease the labour market integration of immigrants. In recent years, many countries have reshuffled – or merely put in place – their integration policies, with emphasis in most cases on language courses, job-oriented initiatives, and anti-discrimination measures (OECD, 2006a). The few empirical evaluations of language training suggest that its impact is clearly positive for newly-arrived immigrants (in particular at the very beginning of their stay), but diminishes significantly over time. There may be a trade-off in cases where formal language training partly keeps people out of the labour market, since early labour market experience has a strong positive influence on employment probability (see Liebig, 2007b, on Australia; and Lemaître, 2007, on Sweden).
- Labour market measures targeting immigrants may also be considered part of these integration policies. For example, a gradually diminishing wage subsidy for newly-hired immigrants was proposed in Denmark as part of an integration policy involving other accompanying measures, such as "in-the-workplace" language and job-specific training. The effectiveness of such measures has not yet been checked, but they are costly to apply, therefore requiring a rapid "phase out" (Roseveare and Jorgensen, 2004). In addition, targeting unskilled, newly-arrived immigrants is disputable, to the extent that other groups (for instance, unskilled second-generation immigrants, or some ethnic minorities) often display comparable difficulties in integrating the labour market.
- Affirmative action and positive discrimination policies are another part of the specific measures aimed at improving immigrants' integration. Economic assessments of affirmative action programmes in the United States suggest that they can redistribute employment and higher education to the benefit of women and ethnic minorities, although to a limited extent, without entailing obvious efficiency costs (Holzer and Neumark, 2000). Little information is available for European countries.

Explaining cross-country differences in the labour market integration of immigrants

The few existing integration studies covering several European countries (Peracchi and de Palo, 2006; Buchel and Frick, 2003;[27] and Adsera and Chiswick, 2004) do not analyse the determinants of cross-country differences in the labour market integration of immigrants. The estimations in Causa and Jean (2007), carried out for a number of OECD countries based on comparable data and methodologies, fill this gap. Standard, individual-level equations, where the dependent variable is either the probability of being active or employed, or the hourly wage rate, are estimated using the same specification for each country. The raw data are drawn for each country from longitudinal household surveys over part of the 1994-2003 period. In each case, the estimations are carried out for data covering both natives and immigrants (assumed to be those individuals born abroad, a limitation imposed by lack of better-suited data), and aim at assessing the influence of immigration background on labour market outcomes.

In order to control for systematic integration differences related to immigrants' country of origin, two categories of immigrants are considered: for European countries, those born within and outside the EU-15 area; for Australia, Canada and the United States and those born in or outside an OECD English-speaking country. In each case, cultural proximity (as well as specific legal treatment in the EU case) justifies such distinction. In practice, the analysis focuses on non-European immigrants (or immigrants whose country of origin is not an OECD English-speaking country), based on the premise that those individuals are the most likely to suffer from weak labour market integration.[28] Length of stay in the host country is also taken into account by distinguishing immigrants who have spent more or less than 15 years in the country,[29] except for the United States due to data limitations.

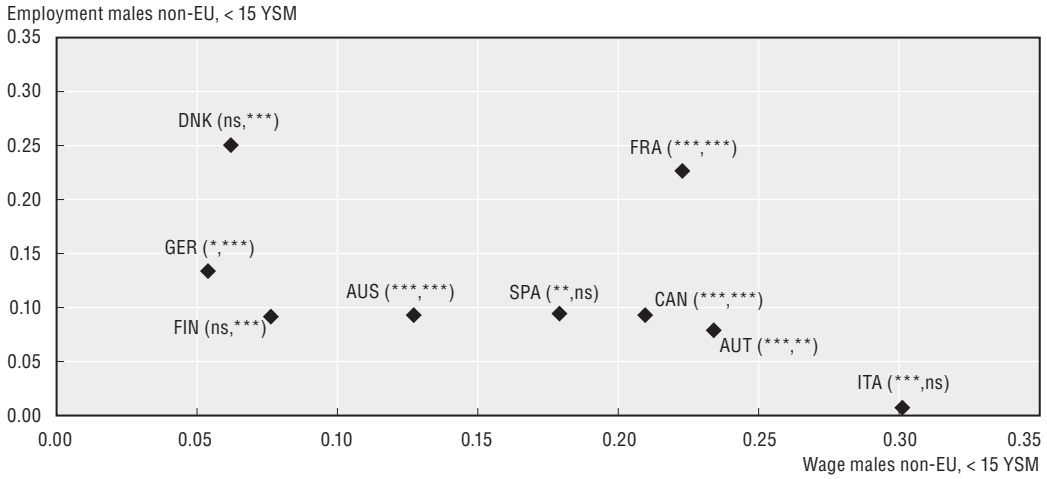
Estimation results by country

Estimates confirm that differences in labour market performance between immigrants and comparable natives were widespread among OECD countries over the 1994-2003 period. Results in the case of European countries have to be interpreted with care, in particular for recently-arrived immigrants, because of the limited representation of this category in the European Community Household Panel (ECHP) sample. Nevertheless, where comparisons are possible, the results are consistent with country studies, except otherwise mentioned.

Although the relatively small number of countries studied does not allow any general cross-country relationship to be established, different typical outcomes emerge from an overview of the results for men with less than 15 years of residence in the host country (Figure 4). Insignificant employment gaps among actives, together with substantial estimated wage gaps (above 15%) in the United States,[30] Italy and Spain,[31] contrast with small or insignificant wage gaps alongside substantial employment gaps found in Denmark and Germany, and to a lesser extent in Finland. Intermediate gaps in both wages and employment are found in Australia (around 10%), while a moderate employment gap coexists with a substantial wage gap (20 to 25%) in Canada and Austria. Finally, France stands out as an outlier, featuring both high wage and employment gaps.[32]

Results not reported here suggest that differences between immigrant and native men are less marked in terms of the probability of being active in the labour market. This is consistent with the stylised fact that activity is generally high among immigrant men. By

Figure 4. **Employment gap *versus* wage gap for immigrants with *less* than 15 years residency (men, non-EU or non-English speaking OECD immigrants only)**



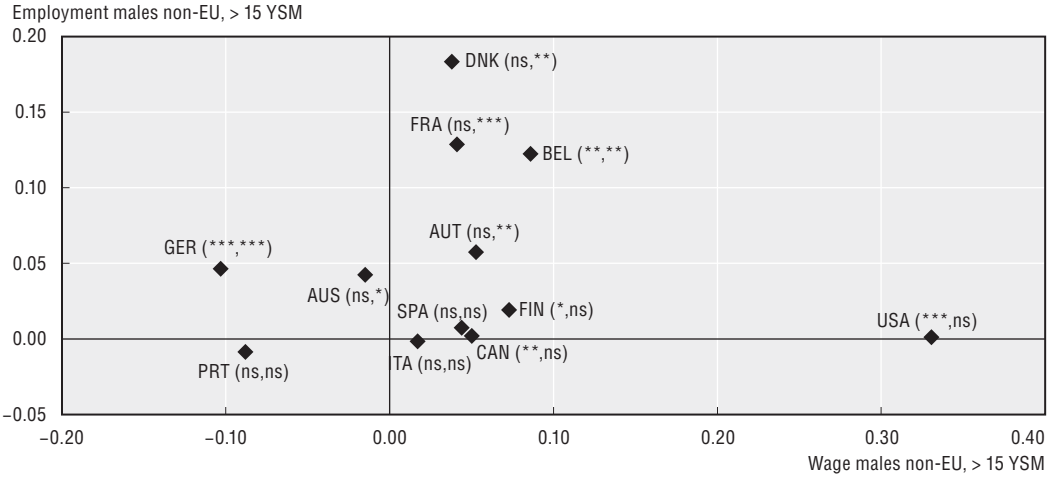
Note: "ns" refers to non significant, *significant at 10%; **significant at 5%; ***significant at 1%. (*, ns) means wage gap significant at 10% and unemployment gap ns.
Non-EU refers to individual not born in a EU15 country. "< 15 YSM" means 15 years or less since migration. For the United States' estimates, year since migration could not be controlled for. For the United States and Australia, the category refers to individuals that were not born in an OECD English-speaking country. "_n" denotes estimation carried out with the nationality criterion, instead of country of birth, to identify immigrants.
The base specification is $y_{ict} = \alpha_{ct} + \gamma_c X_{ict} + \lambda_c I_{ict} + \varepsilon_{ict}$, where y is the labour market outcome indicator under consideration for individual i, in country c, and period t. X is a vector of socio-economic controls, I indicates immigrant dummies and α captures country-level, time-varying unobservable characteristics.
Source: Secretariat calculations based on ECHP, PSID, SLID. Results for Australia were kindly provided by Hubert Strauss based on the HILDA database.

contrast, differences in activity are often significant between immigrant and native women, as a result of both the predominance of family reunification reasons among women's migration motives as well as cultural differences.[33] This activity gap of recently-arrived immigrant females with regard to natives is especially marked in Belgium, Canada, Italy, Germany and Australia. A significant wage gap for this category of immigrants is also found in Canada, Austria and Finland (see Causa and Jean, 2007).

Differences between natives and non-EU or non-OECD English-speaking countries' immigrants are markedly lower for those with more than 15 years of residence in the host country (Figure 5). Although the use of panel data should limit the influence of differences in unobservable personal characteristics across immigrant cohorts, lower estimated gaps for early arrivals may reflect both cohort and assimilation effects. Differences with natives are particularly small in terms of wages, with significant (although moderate) gaps found only in Belgium (for men only) and Canada (for both men and women).[34] By contrast, significant gaps in male employment probabilities persist in Europe (except in the Mediterranean countries), although smaller than among recently-arrived immigrants: the employment probability among immigrants with more than 15 years of residence is lower than that among natives by around 5% in Germany and Austria, by more than 10% in France and Belgium, and by 18% in Denmark. The fact that employment itself is a factor of integration may explain why employment gaps are more persistent than wage gaps.

The persistent employment gap common to Northern Europe (with the only exception of Finland), coupled with the cross-country differences in wage-employment gaps

Figure 5. **Employment gap among actives *versus* wage gap for immigrants with *more* than 15 years residency (men, non-EU or non-English speaking OECD immigrants only)**



Note: "ns" refers to non significant, *significant at 10%; **significant at 5%; ***significant at 1%. (*, ns) means wage gap significant at 10% and unemployment gap ns.
Non-EU refers to individual not born in a EU15 country. "> 15 YSM" means more than 15 years since migration. For the United States' estimates, years since migration could not be controlled for. For the United States and Australia, the category refers to individuals that were not born in an OECD English-speaking country. "_n" denotes estimation carried out with the nationality criterion, instead of country of birth, to identify immigrants.

Source: Secretariat calculations based on ECHP, PSID, SLID. Results for Australia were kindly provided by Hubert Strauss based on the HILDA database.

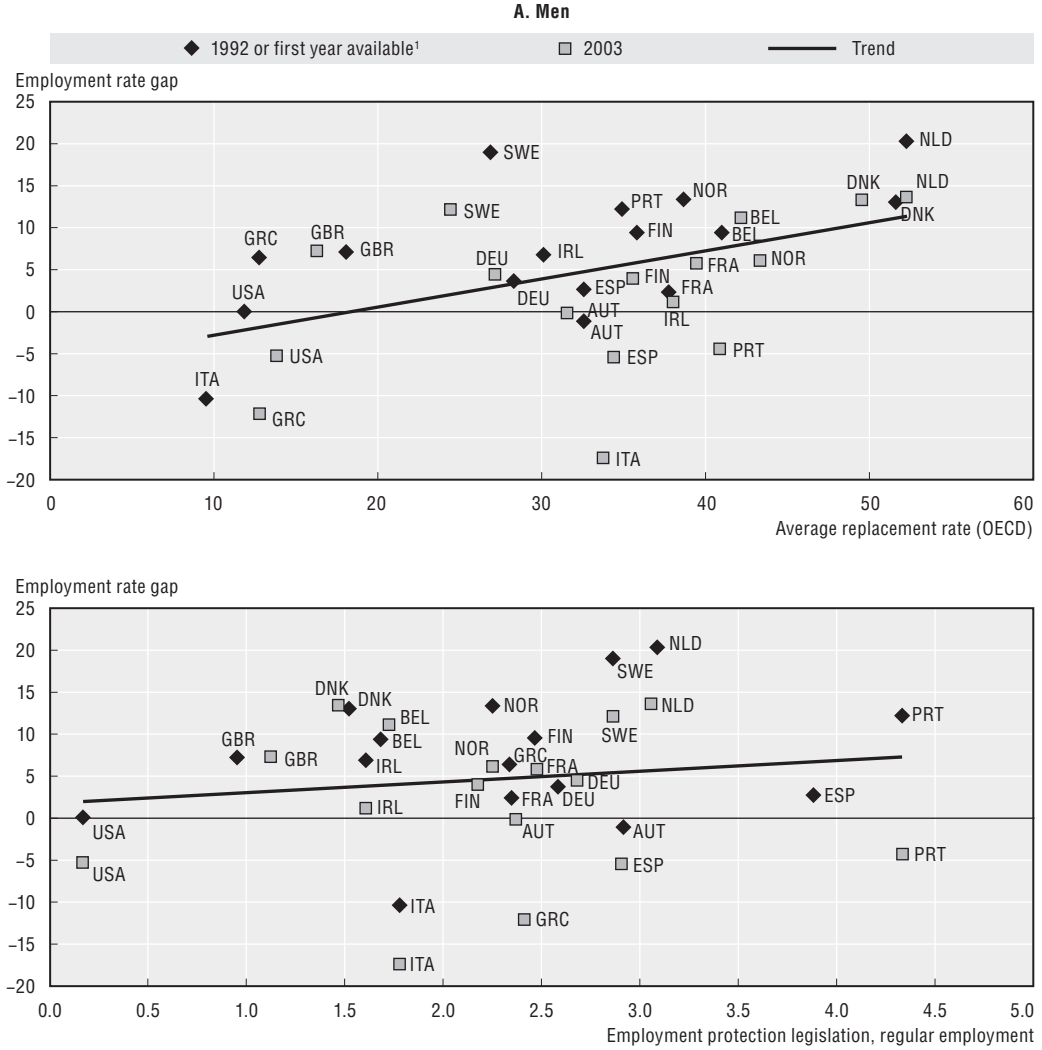
identified for recently-arrived immigrants, suggests that factors other than individual characteristics may be influencing immigrants' labour market performance. In particular, the potential role of labour market policies in shaping the differences in labour market outcomes between immigrants and natives deserves examination.

The role of labour market policies

From a policy point of view, it is important to know whether labour market policies that are known to affect overall employment and wage outcomes also matter for immigrants' integration. As mentioned earlier, immigrants are in many cases over-represented among low-skilled workers. They face specific constraints, notably imperfect language command and, more generally, weak local human capital; moreover, in some cases they have limited access to welfare and unemployment benefits upon arrival. These constraints are likely to lower their reservation wage below that of natives. As mentioned above, their location choices also tend to be more responsive to labour market conditions – and thus possibly to cross-country policy differences – at least as far as new immigrants are concerned (Borjas, 2001).

Given immigrants' specificities, labour market policies do not necessarily affect them in the same way as natives. The focus here is on three sets of policies: income support to the unemployed, employment protection legislation and labour income taxation. The possible relationships between the first two policies and labour market outcomes of immigrants are illustrated in Figure 6, where the employment gap between immigrant and native men is plotted against indicators of, the average replacement rate of unemployment benefits and EPL for regular contracts, respectively.[35] While the scatter diagrams are not conclusive for EPL (the relationship is only weakly significant for low-skilled young men, in

Figure 6. **Immigrant-to-native gap in employment rate and policy variables**



Note: The immigrant-to-native gap in employment rate is defined as (employment rate among natives – employment rate among immigrants), for men (panel A) and for young men (panel B), respectively. The policy variables (EPL and replacement rate) are computed as the country average for the whole labour market, absent well-suited data focusing on low-skilled young men.

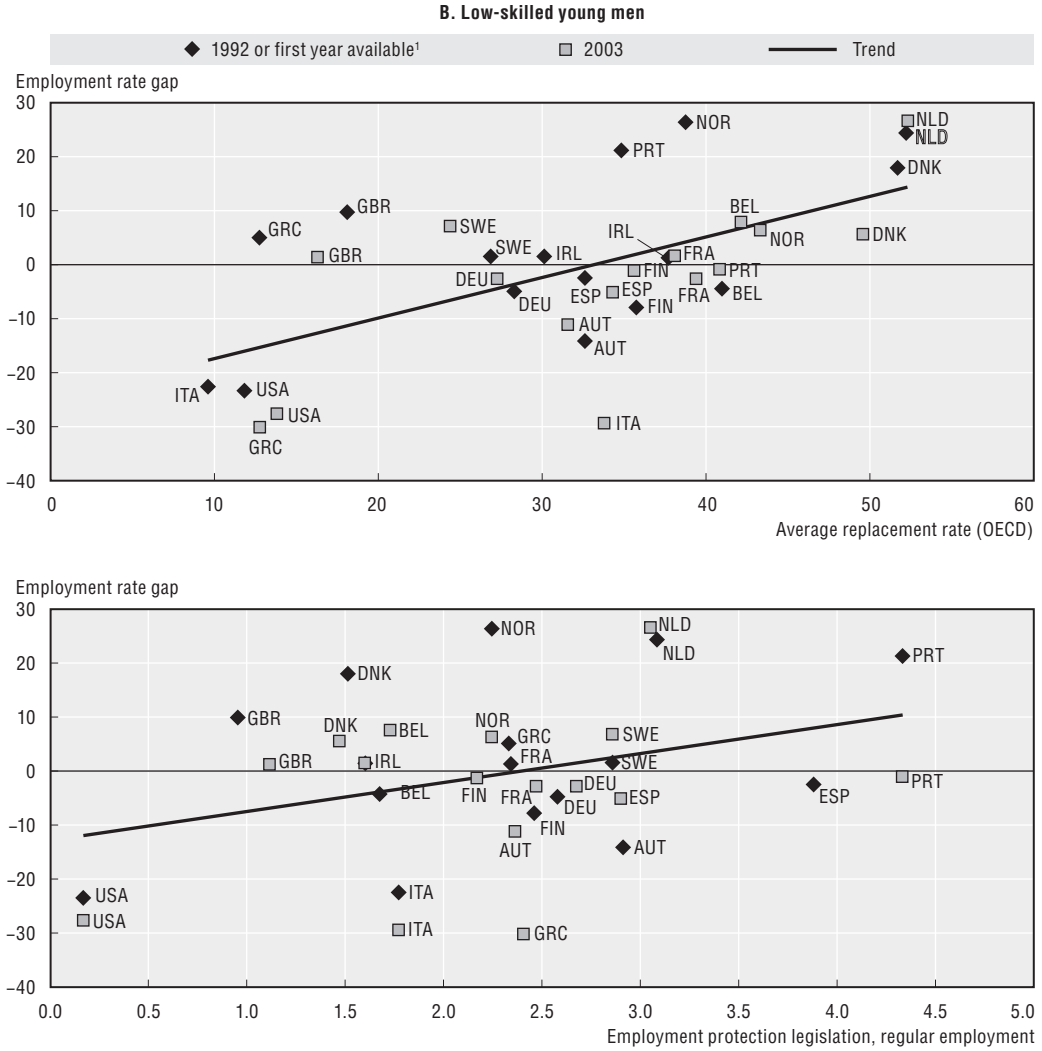
1. 1993 for France; 1994 for United States; 1995 for Austria and Finland; 1996 for the Netherlands, Norway and Sweden.

Source: Secretariat calculations based on European Union Labour Force Survey; US Current Population Survey; NZ Income Survey, Household Labour Force Survey.

Panel B), an upward-sloping relationship is found between the immigrant-to-natives employment gap and the average replacement rate of unemployment benefits.

In order to investigate more rigorously these possible policy influences, Causa and Jean (2007) carry out an econometric analysis pooling the country-specific data sets used in their country-by-country estimations. While data for all countries and periods are stacked to increase variability and degrees of freedom, the coefficients of observable characteristics other than the immigration background are still assumed to be country-specific. The immigration background itself is modelled both through an effect that is constant across countries and time, and through an interaction with policy variables. These interaction

Figure 6. **Immigrant-to-native gap in employment rate and policy variables** *(cont.)*



Note: The immigrant-to-native gap in employment rate is defined as (employment rate among natives – employment rate among immigrants), for men (panel A) and for young men (panel B), respectively. The policy variables (EPL and replacement rate) are computed as the country average for the whole labour market, absent well-suited data focusing on low-skilled young men.

1. 1993 for France; 1994 for United States; 1995 for Austria and Finland; 1996 for the Netherlands, Norway and Sweden.

Source: Secretariat calculations based on European Union Labour Force Survey; US Current Population Survey; NZ Income Survey, Household Labour Force Survey.

terms thus measure how policy variables influence the immigrant-to-native differences in labour market outcomes.

Table 1 summarises the results of these estimations, by showing the sign of those policy interactions found to be significantly different from zero at standard confidence levels (90% or higher).[36] The minus sign in the first row, for instance, means that the employment probability of immigrant men, in comparison to otherwise similar native men, tends to be lower when the net average replacement rate of unemployment benefits is higher; in short, higher replacement rates are more detrimental to immigrant male

Table 1. **Estimated interactions between policies and immigrants' labour market outcomes, relative to comparable natives**

Policy (in a univariate framework)	Activity Women	Employment Men	Wage Women	Wage Men
Net average replacement rate		_		+
Unemployment benefit duratio	_	_	+	+
Tax wedge	–		+	
Employment protection: regular employment minus temporary employment legislation	+	+	_	

Note: The estimated equation is $y_{ict} = \alpha_{ct} + \gamma_c X_{ict} + \lambda_c I_{ict} + \theta\, Pol_{ct} \times I_{ict} + \varepsilon_{ict}$, where y is the labour market outcome indicator under consideration for individual *i*, in country *c*, and period *t*. *X* is a vector of socio-economic controls, *I* indicates immigrant dummies and α captures country-level, time-varying unobservable characteristics. "Pol" refers to the policy variable under study.
The table provides the sign of interaction effects between immigrant dummy and policy variables, when significant. The specification allows for a differential impact on immigrants that have been more or less than 15 years in the country. The sign provided in the table is given when at least one of the two interactions is found significant and, if both are, they are found of the same sign. Each cell is the outcome of one regression: policies enter the equation in an univariate framework. See Causa and Jean (2007) for details.
Source: Secretariat calculations based on OECD and Scruggs (2004) for policy variables and ECHP for microeconomic data. Results for Australia were kindly provided by Hubert Strauss based on the HILDA database. United States not included due to data limitation on years since migration.

employment than to native male employment. The interpretation of the other entries in the table is similar.

Two main tentative interpretations emerge from these estimation results. First, some labour market policies affecting employment levels (see Bassanini and Duval, 2006) may have a "magnification effect" on immigrants. That is, these policies have the same qualitative impact on immigrants' and natives' labour market outcomes, but the magnitude of this effect is significantly higher for immigrants. Such interpretation applies to the results found for the replacement rate and duration of unemployment benefits, in terms of the employment probability of male immigrants, the activity probability of female immigrants and their relative wages. The same result applies to the impact of the tax wedge on the activity and wage gaps of female immigrants. Such magnification is likely to reflect the overrepresentation of immigrants among low-productivity workers, whose labour market performance is generally more strongly affected by these policies.

Second, employment protection on regular contracts *relative* to temporary contracts is used to assess the consequences of labour market dualism for immigrants. This measure was used in OECD (2004b) as an indicator of the incentive for employers to hire with temporary contracts, because easing their regulation would increase the incentive to hire on temporary contracts to a larger extent when permanent contracts are more regulated in addition. Bassanini and Duval (2006) have shown that partial reform of the labour market – lowering protection for temporary jobs, but leaving permanent contracts untouched – encourages temporary job traps and labour markets dualism. A higher relative protection of regular contracts is found to significantly increase the probability of women's activity and men's employment for immigrants, while depressing female immigrants' wages, relative to comparable natives. These results suggest that immigrants are overrepresented among temporary jobs, and more generally among labour market outsiders.[37] A legislation favouring the development of temporary rather than regular-contract jobs would, therefore, disproportionately boost immigrants' employment in precarious jobs; meanwhile, the negative impact found on wages suggest that these jobs tend to offer relatively low pay. Consistent with this interpretation, Causa and Jean (2007) show that,

ceteris paribus, being an immigrant significantly increases the probability for an employee to hold a "fixed- or short-term contract" or "casual work with no contract"

Although caution should be exercised in interpreting these findings, they suggest that in a number of OECD countries immigrants' labour market vulnerability may be reinforced by specific institutional settings: immigrants' labour market outcomes seem to be particularly sensitive to policies that are not employment-friendly or generate labour market dualism.

Conclusion

Drawing on both country experiences and cross-country analysis, two main sets of conclusions can be reached covering, on the one hand, labour market and integration outcomes, and on the other, the role of policies in shaping these outcomes.

Labour market and integration outcomes

- Immigration influences relative wages for individual categories of workers, depending in particular on the skill mix of immigrants. At the aggregate level, however, pressures on real wages are limited and vanish after a few years. In terms of unemployment, immigration of workers of given skill and experience categories do not have much impact on the relative unemployment rate of natives with similar skills and experience. At the aggregate level, an increase in the share of immigrants in the labour force increases unemployment of natives, but this impact is temporary and vanishes between four and nine years after the shock. Beyond this transitory period, the level of the share of immigrants in the labour force does not influence significantly natives' unemployment.
- The labour market integration of immigrants remains a challenge. In all OECD countries studied, for given individual characteristics, immigrants under-perform natives in terms of wages, unemployment, or both. The gap decreases over time as immigrants assimilate to natives, but typically persists even after a long period of stay – especially as far as unemployment is concerned. Because labour market experience in the host country is an important channel of integration, the often low employment rate among recently-arrived immigrants does not bode well for their future labour market assimilation, and extrapolating past trends may be overly optimistic for many countries.
- Even for comparable individual characteristics, immigrant employees are more likely than the native-born to hold temporary contracts, especially when their arrival in the host country is relatively recent.
- Except in a few settlement countries, immigrant students perform significantly worse than the native-born in OECD countries. This also holds, although to a lesser extent, for those children of immigrants born in the country – the so-called "second-generation immigrants". Some catching-up in performance is taking place between one generation and the next, albeit at a slow pace. Migration background-based inequalities are, thus, likely to persist for a long time.

The role of policies

While the evidence on the labour market impact of immigration and the comparative economic performance of immigrants is reasonably well-established and robust, conclusions about the role of migration and other policies in shaping these outcomes cover

relatively new ground and are less robust. OECD countries' experiences in dealing with migration are heterogeneous, and few data are available to assess the effect of policies.[38] Nevertheless, some tentative conclusions arise around three main domains.

The definition and application of effective migration policies

Migration policies, by affecting the types of migrants that enter the country, influence the labour market impact of immigration. They also have an impact on future integration outcomes because immigrants' integration depends strongly on their characteristics, notably in terms of skills, status, immigration motive and country of origin. However, the evidence surveyed in this paper suggests that there are limits to this impact: non-discretionary immigration flows are substantial (*e.g.* family reunification, humanitarian, and illegal); selective immigration policies are difficult to design and manage, and their outcomes do not always meet expectations.

The design of specific integration policies

Policies targeting immigrants' integration are applied by a number of countries. They often focus on language or education support, with some evidence that they encourage integration, though their impact is difficult to gauge quantitatively. Migrant-specific labour market policies are also implemented in some cases, directly influencing immigrants' wages and employability. Targeting unskilled, newly-arrived immigrants is questionable though, since other groups may face comparable difficulties in integrating into the labour market. However, information about these policies is scattered, and more specific analysis would be needed in order to assess their effectiveness in fostering labour market integration of immigrants.

Concerning the education of first- and second-generation immigrant students, more attention needs to be paid to improving literacy skills for students with a foreign language background, notably through targeted policies of language acquisition. Education policies should also consider the risk that early selection would exacerbate the disadvantages faced by students with an immigration background.

The interaction of the broader domestic policy environment with immigration outcomes

The empirical analysis reported in this paper suggests that general labour market policies can influence the labour market impact of immigration. Protection of incumbent workers through employment protection legislation may limit the impact of immigration on natives with characteristics similar to immigrants, but it does not affect significantly the aggregate impact of immigration, which remains transitory irrespective of the policy environment. Excessively strict legislation does, however, slow down significantly the transition by increasing the persistence of the initial increase in unemployment. Meanwhile, both the size of this increase and the length of the adjustment to it appear to be magnified by anti-competitive regulations in product markets that hinder the creation of new firms.

Empirical findings also suggest that reform of the labour market in general may be helpful in accommodating problems specific to migrants through two main channels: the impact on immigrants of policies that are not employment-friendly for certain groups of workers (like high unemployment benefit replacement rates) is qualitatively the same as on natives, but it is magnified; and immigrants suffer disproportionately from labour market dualism.

Notes

1. A number of other policy issues were also identified in the OECD surveys but their implications were less clear in terms of policy lessons and recommendations. See also Leibfritz *et al.* (2003).
2. While immigrants are usually defined as persons born abroad with foreign nationality at birth, the statistical measurement of immigration flows is not harmonised across countries. The main difficulty is that some countries count many shorter term entries and others only permanent immigrants. The OECD figures are the result of an effort to harmonise the raw data. Non-harmonised inflow statistics amount to 1.2 million people for 10 other OECD countries (0.51% of their total population). Although these data are not purely comparable, this leads to the indicative total figure of 3.8 million immigrants arriving in 27 OECD countries in 2004, or 0.36% of their population. The three member countries not covered by this figure are Greece, Iceland and Mexico (see OECD, 2006*a*, p. 30).
3. See, among many others, Borjas (1985, 1995 and 1999), LaLonde and Topel (1991), Chiswick (1986) or Jaso *et al.* (1998).
4. This is not a general rule, but immigrants are likely to have a lower reservation wage than natives as soon as they enjoy limited labour market opportunities, while facing specific constraints, *i.e.* limited eligibility for welfare and unemployment benefits.
5. In some of the surveyed countries there are no available analyses of the labour market impact of immigration (Belgium, Denmark, New Zealand), whereas in others results from empirical analyses are contradictory (Italy) or are considered to be largely affected by the lack of account of illegal immigration (Spain). In Australia and Canada the effect is considered to be small on both unemployment and wages, and blurred by other changes brought about by immigration (*i.e.* higher savings or housing investment by immigrants themselves). In new immigration countries (Czech Republic, Spain), the lack of measurable impact is partly due to the fact that immigrant labour is complementary to native labour, as immigrants take up vacancies that locals do not want to fill (at least in some sectors).
6. A meta-analysis studies a set of results on a given question, in order to characterise the average assessment arising from this set of results, and how it varies according to scope, assumptions and techniques.
7. Earlier immigrants are frequently a good source of information.
8. However, finding the same elasticities does not mean that the impact on wage inequality is the same. Since immigrants in Canada are mostly high-skilled, the relative wages of highly-skilled workers are lowered, thus reducing wage inequality. The opposite effect is found in the United States, where the unskilled workers are over-represented among migrants. In Mexico, emigration of mostly middle-wage workers benefits the "stayers" belonging to this category.
9. Card argues that natives' mobility and output-mix changes are unimportant, while immigrants' absorption mainly occurs within industry. He also observes that the wages of lower-skilled relative to medium-skilled workers have not changed over time, despite the fact that the relative supplies of both types of workers have shifted due to immigration. Although these findings are not easily reconciled with Borjas' findings, they do not refute them. Still, they suggest that the importance of natives' mobility remains limited, and that the global impact of immigration on wages should not be overstated.
10. Due to data limitations, similar analysis cannot be conducted for wages.
11. An alternative is to study employment rates. This does not make a big difference (except for the sign of the results), since immigration does not influence men's participation rate very much.
12. Here experience is assumed to be equivalent in both origin and host countries, although in practice entrepreneurs in the host country do not always fully recognise experience accumulated before entry.
13. It could be argued that regularization processes is South European countries implicitly apply a similar selection process through the labour market, since recent regularizations in those countries have been conditional on having a job.
14. There is also a risk of moral hazard if employers do not face the costs induced by selection errors.
15. The focus here is on non-EU immigrants in European countries and on immigrants from non-English speaking countries in the United States and New Zealand.

16. Among others, on the US: Borjas, (1985, 1995), La Londe and Topel, (1992), and Duleep and Doowhan (2002); on Australia: Chiswick *et al.* (2005); on Canada: Hum and Simpson (2001) and Renaud and Cayn, (2006).

17. Most studies focus on country-specific cases. A number of them have been devoted to the case of Ethnic Germans and Guest workers in Germany (see Bauer and Zimmermann, 1997, Schmidt, 1997). Other examples include: for Germany, Constant and Massey (2003, 2005) and Liebig (2007*a*); for Sweden, Barth and Bratsberg (2004), Edin *et al.* (2000) and Lemaître (2007); for the United Kingdom, Dustmann and Fabbri (2005), and Frijtesr et *al.* (2005); for France, Meurs *et al.* (2006); for Spain, Amuedo-Dorantes *et al.* (2006); for Denmark and Sweden, Blume *et al.* (2003); for Denmark and Germany, Constant and Zimmermann (2004). For a comprehensive review on Europe, see Zimmermann and Constant (2004).

18. Examples leading to this conclusion and involving different techniques include Borjas (1994) and Schawn (2005).

19. See also the OECD Economic Surveys of Spain (OECD, 2003a), which emphasises that most immigrants are not eligible for unemployment or welfare benefits, as many of them are found among labour market "outsiders" (as illustrated, for instance, through their over-representation among fixed-term contract workers), and in many cases are undocumented.

20. For instance, asylum seekers are usually not allowed to work while their application is being processed.

21. Studies on the importance of language include Chiswick and Miller (1995, 1998), Lazear (1995), Berman *et al.* (2003). See Kahn (2004) for an original study based on the International Adult Literacy Survey (IALS) cross-section data.

22. For example, Gregory and Meng (2005) show that there is a wage premium for intermarried (exogamous) immigrants, that does not appear to be a reward for unobservable characteristics. Bauer and Zimmermann (1997) show that ethnic networks are very useful for successful integration into the German labour market.

23. For the United States, see Borjas (1985, 1994 and 1995). See Baker and Benjamin (1994) for Canada.

24. Empirical studies suggest the existence of differences in returns to education between immigrants and natives. Consistent with the findings by Chiswick and Miller (2005), unreported estimates made by the authors suggest that the returns to education are generally slightly lower among immigrants than among natives.

25. For instance, Kaushal (2005) finds no such effect when studying the location across states in the United States, as a result of the Personal Responsibility and Work Opportunity Reconciliation Act (PRWORA), which denied non-citizens who arrived in the United States after August 1996 access to means-tested federal benefits for the first five years (with exceptions subsequently introduced, as well as substitutive benefits offered by some states).

26. Borjas (2003b) shows that the immigrants most likely to be adversely affected by the welfare restrictions implied by PRWORA measures significantly increased their labour supply, thereby raising the probability of being covered by employer-sponsored insurance. Still, Cacari Stone (2004) finds that the new Medicaid restrictions associated to the PRWORA have exacerbated the pre-existing barriers in accessing health care for immigrants, resulting in diminished health outcomes for immigrants.

27. Buchel and Frick (2003) do not control for human capital differences across natives and immigrants. Their results are thus descriptive in nature. Observed differences could be explained by differences in terms of skills distribution, both across countries and across natives and immigrants.

28. EU-15 (respectively, OECD English-speaking) immigrants are in almost all cases either statistically undistinguishable from comparable natives, or better performers.

29. Immigrants that have spent one year or less in the country are excluded from the analysis because it is not possible to control for the representativeness of the sample on that specific category. This is problematic because outcomes for newcomers are known to differ strongly from those of other immigrants, in particular in terms of employment rates.

30. Results for the United States actually do not refer specifically to immigrants with less than 15 years of residence in the country.

31. It is noteworthy that no employment gap is found in the three Mediterranean countries (Italy, Spain and Portugal). This finding may be partly linked to the high activity rate of undocumented

immigrants, some of which are covered by the household data used here. However, the actual coverage of illegal migrants is unknown and probably low.

32. Finding a high wage gap in France may come as a surprise given the relative compression of the wage distribution in that country, in particular among low wages. However, this result only holds for recent immigrants here, while the wage gap is not significant anymore for immigrants in the country for more than 15 years. As mentioned in the next section, Aeberhardt and Pouget (2006) suggest in addition that second-generation immigrants perform as well as natives in terms of wages, at least for comparable occupations.

33. Fernandez and Fogli (2005) show how persistent the cultural influence of the country of origin is in shaping labour market participation behaviour, especially among women.

34. A significant positive wage gap is found for Germany. The explanation of this surprising result is unclear, but may be related to the under-representation of foreigners in the German sample.

35. Labour force survey data are used for this purpose (allowing better representativeness and wider country coverage than the household panel data used in econometric analysis), and each country is represented at both the beginning and end of the period for which the data are available (generally, 1992 to 2003).

36. Causa and Jean (2007) also estimated the impact of statutory or conventional minimum wages. The results are not reported here because the limited coverage of such data across OECD countries makes the corresponding estimates less reliable.

37. On a related note, Reitz and Verma (2004) show that immigrants are less unionised than natives in Canada.

38. This problem is especially acute for undocumented immigrants, whose role and specificities are necessarily overlooked to a large extent in quantitative cross-country analyses such as the ones carried out here.

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New International Evidence on Asset-Price Effects on Investment, and a Survey for Consumption

by
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A survey of the literature on asset price impacts on the real economy shows a much wider range of work on consumption and related wealth effects than on investment. The existence of wealth effects on consumption per se is little contested, but there remains an issue of whether different effects should hold between countries and across assets. On balance we contend that the literature suggests a role for housing and tangible wealth as well as financial wealth as a determination of consumption. In terms of investment there are numerous studies implying that uncertainty and balance sheet effects on investment can both be detected, albeit the latter more in micro than macro studies. In the light of the investment literature, we undertook panel investment functions on a macro basis for up to 23 OECD countries. Developing earlier work, it was found that the main significant effects arising from asset prices come from the financial accelerator, credit channel and Tobin's Q (especially in the G7) and uncertainty as proxied by asset price volatility (especially in smaller OECD countries). There is also evidence for non-linearities in volatility. Descriptive analysis as well as tentative cross-sectional regression showed that both balance sheet and uncertainty channels played a role in the recent financial crisis, when investment fell sharply, although the simple accelerator was also important. The work has implications for monetary, fiscal and regulatory policies, all of which can impact on asset prices and the financial sector and thus via this channel on the wider economy.

JEL classification: *E22, E44, F31, G31*

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The recent financial crisis and the resulting downturn, as well as the boom in asset prices accompanying rapid growth over 2002-07, have led to renewed interest in the role asset prices may play in real activity. This paper seeks to provide an overview of the principal channels whereby asset prices, in particular of equities, may influence the real economy. The paper has two main sections. In the first part a literature review is provided, summarising thematically the state of play and major findings in key areas, as well as highlighting some outstanding questions. In the second part new estimates of equations for business investment for 23 OECD countries are provided. The paper provides a benchmark for assessing the impact asset prices have on this key area of economic activity, which influences both the demand and the supply side of the economy. It also provides background for assessing the impact of the recent financial crisis on investment.

The paper is structured as follows: The literature review in Section 1 provides an overview of the various mechanisms by which asset prices can influence economic activity and reviews macro model results for asset prices' impact on GDP. Section 1.2 summarises analytically what is known about wealth effects on private consumption and reviews the literature on the size of these effects. Section 1.3 surveys the literature on the effects of asset prices on business investment, notably via Tobin's Q, the user cost of capital, the financial accelerator and uncertainty.

In Section 2 business investment equations are estimated for up to 23 OECD countries to show both the statistical and, more importantly, the economic significance of asset price changes for business investment for those countries for which suitable data are available. Hence the focus is on Tobin's Q, the financial accelerator and uncertainty effects, while also including other investment determinants, such as the bank credit channel. Section 2.1 describes the data and sample while Section 2.2 shows the estimation of basic investment functions. Sections 2.3 and 2.4 successively assess the effects of the level and volatility of asset prices in that framework. Section 2.5 shows some variants and robustness checks. Section 2.6 considers how important these effects have been in explaining the recent history of business investment. Section 3 concludes.

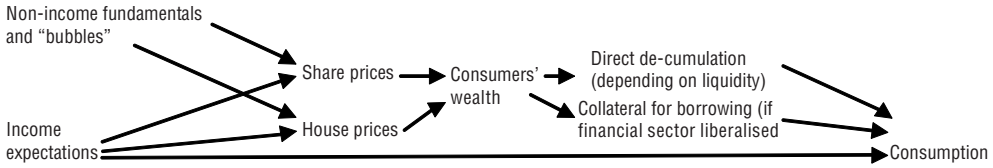
1. Literature survey on asset prices and economic activity

1.1. An overview

In general, the key channels through which asset prices impact on the real economy are via consumption and investment, which will be assessed in more detail in the sections below. In terms of consumption, the impact arises via the wealth effect, which supplements the traditional income effect. This arises mainly through changes in asset prices such as those of shares and residential property. The wealth effect is often claimed to become more powerful after financial liberalisation, because illiquid wealth can then be more easily borrowed against to facilitate consumption, as an alternative to de-cumulating existing assets. Note that asset prices themselves are determined partly by income expectations, which also influence consumption directly. Non-income fundamentals

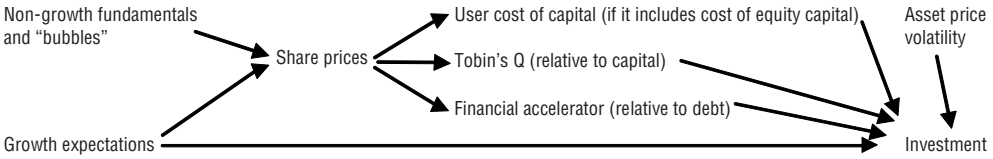
affecting asset prices include interest rates and the risk premium. Indeed, monetary policy can have a major impact on asset prices, but in practice in recent years it has been widely considered that inflation targeting implies it is appropriate to neglect asset prices, unless they risk causing CPI inflation due to excess aggregate demand. Also the possibility of bubbles cannot be ruled out, which may in turn lead to financial crises in the downturn as well as sharp falls in consumption. The major channels for asset price effects on consumption are summarised in Figure 1.

Figure 1. **Channels for asset price effects on consumption**



There may also be a major impact of share prices on business fixed investment, which may operate via Tobin's Q (the valuation of firms relative to the replacement cost of the capital stock), the user cost of capital (if it includes the cost of equity capital) and the financial accelerator (whereby the level of corporate net worth eases concerns of lenders over moral hazard, and hence external finance constraints during a boom, which is reversed in a downturn). Further asset price effects may occur via uncertainty and its impact on business confidence. Note again that share prices are influenced in part by output expectations that also influence investment directly (via the "accelerator"). Also long-term interest rates, which are another key influence on investment, are in part market determined. Figure 2 shows the principal effects of asset prices on investment.

Figure 2. **Channels for asset price effects on business investment**



A number of studies have focused on asset price impacts on GDP, without disaggregating its components. For example, Barrell and Davis (2005a) used a Vector-Error-Correction (VEC) approach for 13 EU countries and the United States using data for real GDP, real equity prices, the real interest rate and the government surplus as a per cent of GDP. Their results suggested that equity prices play a major independent role in the determination of output in both the European Union and in the United States, even in the presence of proxies for monetary and fiscal policy. This effect is consistent across both small and large countries, as well as in bank-dominated and market-oriented countries. Nevertheless, they found a noticeably stronger association between equity prices and GDP in market-based economies. For example, the contribution of equity prices to a variance decomposition of output is around three times greater in the United States, at 50%, than in the larger euro area economies. This is consistent with a greater role of equity finance for

firms, and in the balance sheet of households, in the United States than in the euro area, which is a recurrent theme in the literature on asset prices and the real economy.

In complementary work using the NiGEM macro model,[1] Barrell and Davis (2005b) showed that falls in equity prices have around a three times greater impact on output in the United States than they do in the euro area. They found that there were considerable cross country spillovers of equity price shocks from the United States to the euro area, driven by lower US demand as well as effects on euro area wealth of US shares that euro area investors hold, and share price falls in the euro area *per se*. These results are consistent with the patterns observed in the crisis of 2008. Monetary easing can help absorb such a shock in NiGEM. Fiscal policy loosening can also help offset the effects of a collapse in equity prices, but it will mean higher long-term real interest rates and hence it moderates one of the automatic shock absorbers provided by the market mechanism. Again, the degree of fiscal loosening and its potential medium-term impact on long rates is a key policy issue at present.

Detken and Smets (2004) looked at the effect of asset prices on real economic activity in 38 asset price boom periods since 1970 in 18 OECD countries, where such a boom is defined by a deviation of asset prices (equity and real estate) from trend[2] of over 10%. They distinguished between high-cost and low-cost booms. High cost booms are those which entail major output losses (more than a 3% decline in growth) when asset prices fall. Declines in real estate prices seem to be particularly damaging to output. In some cases of high cost booms there is a banking crisis also. They found that following high cost booms, residential and non-residential investment are both strongly affected. They fall over 6% on average in the first two years of the downturn, whereas consumption falls only by 0.2%. Distinguishing features of preceding booms include rapid growth of money and credit early in the boom, as well as rises in asset prices (but consumer price inflation remains subdued). Monetary policy is looser late in the boom. Real activity and especially investment is much higher relative to trend in high cost booms also, which tend to last longer than low cost booms (Table 1). The authors argue that the patterns are consistent with the financial accelerator mechanism, operating notably via the collateral value of real estate. There is of course now strong evidence that the recent boom up to 2007 was a remarkably high-cost one (Section 2.6).

Table 1. **Asset prices and the real economy in low and high cost booms**

	Average 2 years pre		Average boom		Average 2 years post	
Change in:	High cost	Low cost	High cost	Low cost	High cost	Low cost
Equity prices	12.7	8.1	11.2	13.7	–10.8	–6.6
Real estate prices	0.7	3.8	**9.3**	**6.2**	**–7.3**	**–1.3**
GDP	3.3	3.5	**4.2**	**3.3**	**0.1**	**1.6**
Consumption	3.2	3.5	**4.1**	**3.3**	**–0.2**	**2.3**
Investment	6.1	7.2	7.6	6.3	**–6.2**	**–2.2**
Housing investment	2.7	5.7	4.7	3.5	**–6.9**	**–0.1**
Credit	3.5	4.7	**9.7**	**6.2**	**–0.9**	**1.6**

Source: Detken and Smets (2004). Bold figures show a significant difference between the patterns for high and low cost booms.

Given the strong relationship between banking crises and falls in real activity (see for example Hoggarth and Sapporta, 2001), it is also relevant to note the literature linking asset prices to banking distress. A key article is by Borio and Lowe (2002) who showed (using a signal extraction methodology) that deviations of credit and asset prices from prior trends were good indicators of future banking problems. This result is supported by other work such as Barrell *et al.* (2010a) using logit estimation who showed that in OECD countries, a helpful predictor of banking crises is rising house prices lagged three years, as well as banking sector capital and liquidity ratios. The corollary is that regulatory policy can have a key role in protecting the economy from the impact of asset price falls on bank solvency, as well as possibly attenuating the initial rise in asset prices (Davis and Karim, 2010).

Having assessed overall impacts of asset prices on the economy, the focus turns to the empirical work relating asset prices to consumption and investment.

1.2. Wealth effects and private consumption

1.2.1. Theoretical considerations

It is usually assumed that aggregate consumption is largely a function of current real disposable incomes, and such an explanation is indeed consistent with the most basic textbook analysis of consumption based on Keynes' absolute income hypothesis and its popularisation by Hicks and Hansen. However, as discussed *inter alia* in Deaton (1992) and Muellbauer and Lattimore (1995), such an explanation is inadequate, because it leaves out flow and balance-sheet effects relating to personal saving and wealth, which become of particular importance when financial systems are liberalised. These flow and balance sheet effects also imply an impact of asset prices on consumption that would be absent in the traditional income-based equations.

These additional effects and their link to income can be rationalised in the context of the life-cycle hypothesis of consumption and saving. This framework forms the baseline for a great deal of empirical work on consumption, suggesting that consumers accumulate assets during working life so as to live on the surplus during retirement (Ando and Modigliani, 1963). Accordingly, planned consumption is a function of total wealth, based on human wealth and non-human wealth. This can be seen in the version of the life-cycle hypothesis as derived in Deaton (1992). In this model, planned consumption (C^*_t) is a function of total wealth. Total wealth is the sum of human wealth (H_t) and non-human wealth (W_{t-1}).

Planned consumption can accordingly be expressed as a function of H_t and W_{t-1}:

$$C_t^* = m\left(H_t + W_{t-1}\right) \quad [1]$$

where m is the marginal propensity to consume (MPC) out of total resources on average across the population. Meanwhile, unobservable human wealth can be proxied by some function k of current labour income (*i.e.* $H_t = kY_t$). The coefficient on human wealth (*i.e.* income) will be boosted when there are liquidity constraints on the availability of credit, since it implies that current consumption is closely tied to receipts of current income. Ultimately, with liquidity constraints and no liquid wealth, the equation would reduce to the naïve Keynesian equation with income only.

More realistically, the ability to consume out of wealth, and in particular illiquid wealth, is enhanced when there are no liquidity constraints, and such wealth can be used to enhance consumption smoothing over time-either directly via de-cumulation or as security for borrowing. Hence one should expect that the dynamics of adjustment and the

long-run equilibrium in consumption equations will be influenced by the existence of liquidity constraints and these in turn will be linked to financial liberalisation.

Aron and Muellbauer (2000) identify the following effects after liberalisation. First, there are lesser credit constraints on households that expect income growth and are seeking to smooth consumption; second, smaller deposits are needed by first time buyers of housing and some durables; and third, there is a greater availability of collateral-backed loans for households that already own collateral, such as houses. Lacking these, one might expect to see a relatively larger role for recent changes in income in systems with more liquidity-constrained consumers, whilst financial and especially non-financial wealth may have less influence when liquidity constraints are important.[3]

An indicator of the incidence of liquidity constraints, and hence of asset prices, can be constructed from the relative size of both the short and long-run coefficients on income and those on financial and non-financial wealth terms in the consumption function. When there are no credit constraints, as in a liberalised financial system, the impact of current income in the short and long run should be lower, since consumers can borrow to cover shortfalls in income. Correspondingly, the short and long-run impact of wealth will be greater, since it can be either directly de-cumulated or used as collateral for borrowing (Iacoviello, 2004, 2005).

1.2.2. Research using net financial wealth

1.2.2.1. Error correction models giving rise to short and long-run effects. A number of recent studies at the macro level have estimated autoregressive-distributed lag consumption functions using net financial wealth[4] based on the theory above. Often this is set in an error correction framework where short-run can differ from long-run effects, and long-run equilibrium is reached only gradually. Such error correction models can be single-equation or in vector error correction form where all relevant variables are mutually interdependent.

For example, in Davis and Palumbo's (2001) study of the US consumption function, they attempted to determine whether changes in net financial wealth affect the growth rate of consumer spending. They examined quarterly aggregate US data from 1960 to 2000 and modelled long-run relationships to investigate whether (logged) consumption (C), income (Y) and wealth (W) share a common trend, using the following equation, based on [1] above, before setting out short-run dynamics in an error-correction framework.

$$\ln C_t = c_0 + \alpha \ln Y_t + \beta \ln W_{t-1} + \xi_t \ , \qquad [2]$$

They found that there is a statistically significant long-run wealth effect on consumer spending. Ludvigson and Steindel (1999) also examined wealth effects in a log-linear long-run consumption relationship and found a statistically significant wealth and income effect using dynamic OLS. They also showed using a vector-error-correction approach that these variables share a common trend, using quarterly US data.

Internationally, Barrell, Byrne and Dury (2003) found evidence of an effect of net financial wealth as well as real personal disposable income (RPDI) on consumption in the European economies, and tested in a panel context for differences between European countries. Using a pooled-mean-group methodology,[5] they found that it is possible to show that France, Germany, the Netherlands and Austria have similar consumption behaviour with significant financial wealth effects, but with some difference in the dynamics of adjustment.

Following the discussion of liberalisation and liquidity above, it can be argued that disaggregation of net financial wealth is appropriate given the differing characteristics of components of wealth, notably liquidity. Byrne and Davis (2003a) analysed the impact of disaggregated net financial wealth on consumption for the G7 countries, and found that, contrary to earlier empirical work, illiquid financial wealth (equities, bonds, life insurance and pension assets less mortgage debt) scaled by personal disposable income, tends to be a more significant long-run determinant of consumption than liquid financial wealth (deposits and money market instruments less other debt). The results also held when income was proxied by labour income, where the latter is more theoretically correct since RPDI, commonly used in most macro consumption studies, includes part of the return on wealth (rent, interest, profits, dividends) as well as the return on human capital. But as noted by Dreger and Reimers (2009), consistent labour income measures are hardly available in an international setting.

Byrne and Davis (*ibid.*) suggested that this pattern reflected a shift from liquidity constrained to life cycle behaviour following financial liberalisation, and also a more diversified pattern of wealth holding. It may also be that given its lower rate of return, liquid financial wealth is held more as a means of transactions, or for precautionary purposes than as a long-term store of value. Their results have implications for aggregate studies as the relationship of wealth to consumption may change if the composition of wealth changes.

The log transformation in these and most other recent empirical papers is justified by the argument of Campbell and Deaton (1989) that the variables consumption, income and wealth are unlikely to be difference stationary in levels but they are in logs. A counter argument presented by Altissimo *et al.* (2005) is that the elasticity as generated by log models is constant only if the wealth consumption ratio is constant, which they suggest recommends direct estimation of marginal propensities to consume in a linear framework. Furthermore a log framework can only approximate the consumption relation derivable from the intertemporal budget constraint. In other words, the accumulation of wealth can only be modelled precisely with a linear specification.

A notable feature of the results highlighted above for net financial wealth – as well as those for wider measures of wealth cited below – is that the long-run wealth effect seems to vary significantly between OECD countries, being typically higher in the English-speaking countries. Table 2 summarises the results of international studies. It shows that the United States and Canada in particular have high marginal propensities to consume out of net financial wealth (mpcw). Labhard *et al.* (2005), while finding similar results in a VAR-based estimate of aggregate consumption for 11 OECD countries, contest the theoretical basis for differing elasticities and corresponding mpcws.[6] They note that in theoretical models, the determinants of the mpcw such as the intertemporal elasticity of substitution of consumption, the real interest rate and the probability of death (planning horizon) are similar and only taxes tend to differ markedly. Equally, as shown in Altissimo *et al.* (2005), time-series estimates of the so-called deep parameters of theory based consumption functions such as Sefton and In't Veld (1999) and Willman *et al.* (2003) who estimate overlapping generations models are more similar across countries than are more conventional econometric estimates.

Labhard *et al.* (2005) contend that other factors which might lead to cross-country variation, such as distribution of financial wealth, and differing forms of wealth, are not

Table 2. **Estimates of long-run effects of total wealth on consumption (marginal propensity to consume)**

	Wealth definition	Canada	France	Germany	Italy	Japan	UK	US
Ludwig and Slok (2004)	NFW	4.0	1.4	2.0	3.0	4.0	4.9	4.0
Byrne and Davis (2003)	NFW	4.0	3.0	2.0	2.0	1.0	2.0	6.0
Labhard *et al.* (2005)	NFW	7.8	0.8	7.8	2.8	4.2	5.6	3.7
National estimates			1.6	4.4	1.5-2		2.0	4-6
Bertaut (2002)	NTW	8.3					4.3	5.4
Barrell and Davis (2007)[1]	NTW		3.6	3.7		2.4	4.8	6.6
Barrell and Davis (2007)[2]	NTW		2.9	2.5		1.3	2.6	7.1
Memo: average of studies		**6.0**	**2.2**	**3.7**	**2.4**	**2.6**	**3.7**	**5.4**

1. Prior to liberalisation (based on 1980 consumption/wealth ratio).
2. Post liberalisation (based on 2001 consumption/wealth ratio). Wealth definitions: NFW: Net financial wealth, NTW net total wealth.

Source: Altissimo *et al.* (2005), Byrne and Davis (2003a), Barrell and Davis (2007).

sufficient to account for the differences shown in Table 2. Rather, they suggest that estimated differences are attributable to measurement errors (notably in respect of unquoted equities, whose importance varies sharply between countries) and the influence of common shocks to consumption and wealth. In a pooled-mean-group panel relating the consumption/income ratio to the wealth/income ratio, but where short-run dynamics are allowed to differ, they found they could not reject a common long-run mpcw of 6%. Evidence of non-linearities (a lower mpcw for larger changes in wealth) and asymmetries (a larger mpcw for rising wealth) were also found.

1.2.2.2. Distinguishing transitory *versus* permanent shocks. Building on Lettau and Ludvigson (2001), which found fluctuations in the aggregate consumption/wealth ratio useful for predicting stock returns, Lettau and Ludvigson (2004) for the United States and Blake *et al.* (2003) for the United Kingdom examined the distinction between transitory and permanent shocks to wealth and their impact on consumption. They showed that most of the variability of consumption is driven by permanent shocks, whereas most of the variability of equity prices is transitory. Consistent with this is theoretical work by Millard and Wells (2003) who show that shocks to equity risk premia linked to equity volatility have no effect on consumption, while other shocks lead to a positive correlation of wealth and consumption.

Lettau and Ludvigson's work is also a critique of the conventional single-equation work on consumption and net financial wealth reviewed in Section 1.2.2.1. This is because an empirical conclusion regarding the different impact of transitory and permanent shocks to wealth can only be drawn from a vector error correction system as opposed to a single equation error correction model. A single equation assumes that all the adjustment to long-run disequilibrium comes from consumption, whereas these studies find that it is wealth and not consumption that adjusts to restore the long-run equilibrium in the United States and the United Kingdom. A corollary is that conventional estimates of the mpcw may overstate the response of consumption to a change in wealth, if most changes in wealth are transitory.

Tan and Voss (2003) for Australia and Chen (2006) for Sweden report similar results. On the other hand, Hamburg *et al.* (2005) for Germany find that it is income and not wealth or consumption that error-corrects, consistent with stability of asset values in that country.

Failure to account for the transitory-permanent distinction may be another reason for the above-mentioned difference in cross-country estimates of the mpcw.

1.2.2.3. Selected micro studies. Our main focus in this paper is on studies using macroeconomic data. However, micro work using survey data can often answer questions that macro data cannot. For example, as noted by Paiella (2009) macro data cannot readily distinguish the hypotheses that the wealth effect is direct (*i.e.* due to higher wealth leading to greater consumption), indirect (due to easing of collateral constraints on borrowing) or driven by common macroeconomic factors as suggested by King (1990). These alternative paths of influence are shown in Figure 1 above. Using micro data allows tests to be run on the source of wealth effects from financial assets. For example, Maki and Palumbo (2001) for the United States found evidence for a direct wealth effect, in contrast to Paiella (2007) for Italy whose evidence was more consistent with indirect effects.

1.2.3. Studies incorporating tangible wealth

1.2.3.1. Theoretical considerations. Net financial wealth obviously omits a major component of household wealth, namely housing and at a first glance it is natural to argue that wealth effects can arise from housing in the same way as from net financial wealth. But some would argue that even in a liberalised financial system, a strong effect on consumption of non-financial wealth and notably housing is unlikely. One argument is that both housing and consumption could be affected jointly by other factors, notably income expectations (King, 1990). Even if there is a short-term effect of housing due to collateral effects, in the long run it can be argued that the positive effect of higher house prices is offset by the increase in opportunity cost of housing services (Buiter, 2004). Furthermore, the benefits of higher house prices to incumbents is offset by costs to new entrants (Aoki *et al.*, 2002) and higher rental prices for tenants. Housing unlike financial wealth may be held as an end in and of itself, and people may be unaware of short-run gains and losses (Case *et al.*, 2005). These views were quite influential in the period 2000-07 before the financial crisis and helped to promote "benign neglect" of rising house prices that in fact were arguably generating a mutually reinforcing spiral with consumption, and an unsustainable level of output.

Despite these arguments, a number of studies have looked explicitly at tangible wealth as a consumption determinant, while noting this theoretical issue regarding the existence of a housing wealth effect, and bearing in mind that data problems in this area may be more severe than for financial wealth. On the other hand, omission of housing wealth effects, if they exist, could be important economically as consumption would tend to be under-predicted during housing booms. In this context, Paiella (2009) suggests that unlike for financial wealth there may be good reasons for housing wealth effects to differ across countries. For example, there may be differences in scope for mortgage equity withdrawal, as well as in the transactions costs of buying and selling houses that could affect this elasticity.

1.2.3.2. Macro studies of housing wealth effects. Most studies are national such as Murata (1994) for Japan, Barrell, Choy and Riley (2003) for the United Kingdom and Dvornak and Kohler (2003) for Australian States, which all found a positive effect of tangible as well as financial wealth on consumption. Pichette (2004) finds for Canada also that the housing wealth effect exceeds the financial wealth effect, using a VECM approach similar to Lettau and Ludvigson (2001). Carroll *et al.* (2006) for the United States again found that the housing wealth effect is considerably larger than the financial wealth effect, with a short-run mpc

from housing wealth of 2% but a long-run one of 9%. This is not in line with the theoretical implication that housing wealth effects should be smaller, being partly offset at a macro level. It may be that housing has a higher elasticity since it is more evenly distributed.

Internationally, Boone *et al*. (2001) obtained some significant long and short-run wealth effects on consumption in the G7 when disaggregating wealth into financial, housing and other wealth. Barrell and Davis (2004) estimated consumption functions for the G5, on a country-by-country and on a SUR panel basis (including pooled mean group estimation), which encapsulate roles for both financial and tangible wealth, where the latter is closely linked to the value of the stock of privately owned housing. Results suggest that housing-related tangible wealth plays a distinctive role in the determination of consumption in the short- and long-run. The restriction of an identical long-run elasticity for financial and tangible wealth could not be rejected by the data (implying that the mpcw varies with the consumption-wealth ratio). They also detected a marked negative effect of real interest rates. Case *et al*. (2005) found high housing wealth elasticities, well in excess of those for financial wealth, in a 14-country panel.

1.2.3.3. Studies using house prices as a measure of tangible wealth effects. An alternative indicator of tangible wealth is non-financial asset prices, although it may be seen as an inferior approach since it does not allow for asset accumulation via saving as an alternative source of rising wealth to increases in valuation of existing assets. Analysis suggests that these have played a role in the evolution of consumption in many countries. Using GLS panel estimation for 19 countries, Barrell, Davis and Pomerantz (2006) found such a role for house prices in consumption, where the short-run effect of a given rise in house prices on consumption far exceeded that of net financial wealth. One reason for this result may again be that housing is more evenly distributed than financial wealth, and also it can be readily used for collateral in borrowing in a liberalised financial system. The impact of house prices may also be enhanced by leverage. It is clear that few individuals would borrow four or five times their income and put in 10% equity to buy stocks, but few individuals seems to hesitate to do this when it comes to buying a house. With a high leverage, a relatively small increase in the asset price generates substantial absolute gains for the individual. With a liberalisation of financial market and the possibility to take out additional debt, one would expect this effect to be larger in more recent years.

Ludwig and Slok (2004) also used house prices as a measure of tangible wealth (as well as stock prices for financial wealth)[7] and found that for economies with market-based financial systems such as the United Kingdom and the United States, the long-run elasticity of consumption to stock prices is 10% while in bank-based systems such as Germany and France it is 4%. Meanwhile the elasticity for house prices is double that of equity prices. Dreger and Reimers (2009), on the other hand, found consumption's elasticity with respect to house prices in the EU to be 2.5% while for financial assets it is slightly higher at 3%.

1.2.3.4. Complementary micro studies. As is the case for net financial wealth, micro studies permit a deeper investigation of factors underlying tangible wealth effects. For example, Attanasio *et al.* (2005) used micro data to investigate the role of house prices in UK consumption and found that households' responses are consistent with consumers responding to changing perceptions of income and productivity and not real wealth gains. It is hence inconsistent with a wealth effect and can rather be seen as a mis-measured income effect as argued by King (1990).

They also found house prices affect the consumption of young people more heavily, a group also most likely to be credit constrained and less likely to own houses. This contrasts with a similar study for the United States where Campbell and Cocco (2005) found it was the old whose response to house prices was greater. Campbell and Cocco's results also differed from the UK results in suggesting that it is release of borrowing constraints (*i.e.* a true wealth effect) and not the common causality channel that accounts for housing wealth effects. Equity release in the United States by existing homeowners is likely to be underlying the Campbell and Cocco result.

Looking at micro data for Italy, Guiso *et al*. (2006) found that home owners have a positive wealth elasticity, while for renters it is negative and counteracts a housing wealth effect in aggregate in that country in the way theory suggests. It could be argued that the relatively low levels of mortgage borrowing in Italy may underlie this result, by restraining the wealth effect for home owners. These different patterns across countries are consistent with the comment regarding the impact of different institutions by Paiella (2009) cited above.

1.2.4. Empirical work related to the Euler equation

The above research is based on structural or reduced-form equations based on the life-cycle hypothesis, giving a role for asset prices via the relationship of non-human wealth to consumption. There is an alternative approach to the theory of consumption based on the Euler equation, which seeks to aggregate the optimal intertemporal consumption decision of a representative consumer characterised by rational expectations (Hall, 1978). This suggests that consumption should be a random walk with a positive discount factor such as the real interest rate being the only relevant driving variable. The discount factor proxies the effect on consumption of intertemporal substitution ("the reward from saving"). Other asset price effects are accordingly excluded.

While there is extensive empirical work based on such equations for the United States, it has become increasingly clear that, in practice, consumption is predictable with the use of additional lagged variables, notably lagged income changes (Campbell and Mankiw, 1989) and wealth effects. Furthermore, the Euler approach in its purest sense leaves out long-run information on the relationship between assets, income and consumption – and may suffer worse aggregation problems than "solved out" equations incorporating lags (Muellbauer and Lattimore, 1995).

The theory is also vitiated by its assumption that all consumers are unconstrained in credit markets; instead observed behaviour may be the result of some consumers optimising along an Euler relationship whilst others adjust consumption in relation to their current income (Sarantis and Stewart, 2003). Consistent with this, Benito and Mumtaz (2006) looking at micro evidence on UK consumers' behaviour showed empirically that around 20-40% of consumers show excess sensitivity to income over and above the Euler equation, suggesting liquidity constraints or a desire for precautionary saving. Collateral from housing appears to be important in easing such constraints for the constrained group since capital gains boost their consumption. On the other hand, a key cause of excess sensitivity is a high level of debt, and especially negative home equity.

Barrell and Davis (2004, 2007) show that it is possible to nest an Euler specification within an autoregressive distributed lag (ARDL) model by including the current real interest rate in the equation. The results show that consumption is not appropriately modelled as

a function of the interest rate alone, given the additional significance of differenced and levels terms in consumption itself, income and total wealth. Also since the estimated interest rate effect is negative, it suggests that the Euler view is not supported. Rather, the data support traditional intertemporal consumption theory with point expectations or certainty equivalent interest rates, which has a mix of substitution, income and wealth effects from interest rates – and the importance of asset prices is underlined.

1.2.5. The wealth effect and financial liberalisation

Some studies have probed the evolution of consumption behaviour as financial liberalisation proceeds and its effects filter through. One method is to split the sample at the point of liberalisation (Brechetta and Gerlach, 1997; and Miles, 1994). This obviously allows all of the coefficients to vary, at a cost of missing long-run patterns with relatively short samples. Some other tests have been rather restrictive in terms of allowable changes in behaviour. For instance, Miles (1994) introduced a flow variable, housing equity withdrawal, to proxy for financial liberalisation, which is defined as new borrowing secured on housing that is not invested in housing. Zero-one dummies for financial liberalisation are employed by Bayoumi (1993) with a path that rises with consumer credit and in Sefton and In't Veld (1999).

Barrell and Davis (2007) estimate the impact of financial liberalisation on consumption in seven major industrial countries, by applying separate dummies based on dates of liberalisation to the components of an error-correction consumption equation. They find a marked shift in behaviour, notably a decline in short-run income elasticities and a rise in short-run wealth and interest rate elasticities, as well as a rise in long-run wealth effects. A corollary is that consumption equations estimated over both pre- and post-liberalisation regimes may be misleading, and either a form of testing as presented here or a shortening of the sample period may be appropriate for accurate forecasting and simulation.

As noted by Paiella (2009), a weakness of long time-series specifications with time-fixed coefficients is that they require a stable long-run relationship between consumption, labour income and wealth. Institutional changes such as financial liberalisation as well as aspects such as institutions, demographics and taxation vitiate this assumption. Carroll *et al.* (2006) proposes a new method for estimating the size of wealth effects on macro data that exploits the sluggishness of consumption growth and does not require the existence of a stable co-integrating vector. Slacalek (2009) applies this approach to 16 OECD countries, testing for housing and financial wealth effects. He finds larger wealth effects outside the euro area than within it, and that housing wealth effects rose markedly after 1988 in the wake of financial liberalisation.

1.2.6. Conclusions on wealth effects for consumption

There is little question regarding the existence of wealth effects on consumption but rather there is controversy over their cross-country variation, and whether they extend to tangible as well as financial wealth.

It is clear that short-run effects are bound to vary due to differing financial systems and cultural attitudes. Whereas the arguments of Labhard *et al.* (2005) that long-term effects should be the same are quite persuasive, the weight of evidence still favours differing long-run effects, which as noted by Barrell and Davis (2007) may themselves vary as financial liberalisation proceeds.

Furthermore, the evidence for tangible wealth effects as well as financial wealth is well supported. This underlines the importance for all countries of ensuring that there is adequate, accurate and timely data on the complete balance sheet of the household sector. The arguments for different long-run housing wealth effects across countries are arguably stronger than those for net financial wealth, given the wide differences in housing finance systems. On the other hand, there remains some evidence, notably at the micro level, supporting the contention that the housing wealth effect is actually an income-expectations effect.[8]

The work on vector-error correction models shows that conclusions from single equation models on the adjustment of consumption, income and wealth needs to be accepted cautiously. These VEC models are also a useful way of distinguishing transitory and permanent shocks to wealth which may have different effects on consumption.

Macro data are unable to address the issue of the precise channels of wealth effects. Complementary micro studies have shown conflicting results across countries in this regard. They also show that different groups in the population may have differing behaviour (notably arising from variation in liquidity constraints) that may impact on aggregate consumption equations. There may not only be cross-sectional heterogeneity but also over time, given changes in the environment for consumption such as financial liberalisation. A variety of studies have shown an evolution in consumer behaviour, generally entailing increased wealth effects over time.

Some areas where further research is needed include the impact of wealth effects on durables, and on disaggregation of financial wealth, for which there are very few recent studies.[9] Furthermore, research naturally concentrates on countries where there are established datasets – more work on transition countries could also be helpful. And the response of consumption to the current financial crisis warrants careful study, as it seems to have been accompanied by a return of liquidity constraints for some households.

1.3. Asset prices and business investment

A first strand of the literature on business investment and asset prices is on the effect of the level of asset prices. The second field of work looks at asset price volatility. These will be discussed in turn.

1.3.1. Basic considerations – the neo-classical model and Tobin's Q

Modern theories of aggregate investment behaviour, and resultant empirical work, have developed from the neo-classical model first proposed by Jorgensen (1963) and the Tobin's Q model originally due to Tobin (1969) and Brainard and Tobin (1968). As discussed *inter alia* in reviews of investment theory by Chirinko (1993) and Caballero (1999), both models assume that firms seek to maximise shareholder value.

The neo-classical model is itself an extension of simple accelerator models according to which it is output-expectations that determine investment, but augmented to include the effects of relative price variables, specifically the user cost of capital. This is ideally computed from the purchase cost of the additional capital, the rates of interest on bank loans and bond issues, the cost of equity finance, depreciation and the levels of relevant taxes. Alternatively, the Q-theory of investment argues that the level of investment is determined solely by the ratio of the future marginal returns on investment, relative to the current marginal costs of investment.

In the neo-classical model the firm maximises the discounted flow of all future profits, with adjustment costs assumed to be absent. If one assumes that the production function is characterised by a constant elasticity of substitution between capital and other inputs, then one can obtain the following familiar relationship between the desired capital stock, the level of output and the user cost of capital, from the static first order conditions of the firm's maximisation problem

$$K^* = \frac{\alpha Y}{C_k^{\sigma}} \qquad [3]$$

where K^* is the desired level of the capital stock, Y is the level of output, C_k is the user cost of capital (otherwise referred to as the rental cost), α is a function of capital and labour and other factors, and σ is the elasticity of substitution parameter between inputs in the production function. The user cost of capital may be defined as:

$$C_k = P_k(r+\delta)\frac{(1-tdep-tcred)}{(1-t)} \qquad [4]$$

where P_k is the purchase price of a unit of capital, *r* is the real post-tax financial cost of capital (weighted average cost of capital), δ is the depreciation rate of capital (assumed to be geometric), *tcred* is the rate of investment tax credit, *tdep* is the discounted rate of depreciation tax allowances and *t* is the rate of corporation tax. *r* in turn, weights together the cost of equity, bank loans and bond issues. By assuming either that net investment is determined as a distributed lag process of changes in the desired capital stock, or that there are explicit costs of adjustment, it is possible to obtain an investment function for empirical estimation that equates the level of investment to the capital stock in the previous period, lags of the change in the level of output (the "accelerator") and the user cost of capital. Asset prices affect this approach to the extent that the equity risk premium enters the weighted average cost of capital, or varying risk premia on corporate bonds affect the marginal cost of debt finance.

Q theory argues that investment should be an increasing function of the ratio of the capitalised financial value of the firm relative to the replacement (purchase) cost of the unit of capital. Hence asset prices enter directly. Abel (1980), Hayashi (1982) and Lucas and Prescott (1971) have shown that if Tobin's Q is included in the firms optimisation problem with adjustment costs, then investment is dependent solely on the level of *marginal* Q. Marginal Q is the ratio of the future marginal returns on investment, relative to the current marginal costs of investment. Values of Q above one will provide a stimulus to investment. Marginal Q is unobservable, only average Q can be measured, which as noted is the ratio of the market value of the firm to the replacement cost of capital. However Hayashi (1982) demonstrated that when the production and adjustment cost functions adhere to certain homogeneity conditions (implying *inter alia* that there is no market power) then marginal and average Q are equal. So in practice empirical researchers have included measures of average Q in their investment equations. Then one can write the investment equation most simply as:

$$I = \beta Q \qquad [5]$$

where β is a strictly positive parameter. If Q is greater than one investment should be undertaken and the capital stock increased, because the cost of equity finance is below that of purchasing new equipment, whereas for values of Q less than one further investment should not be undertaken and the capital stock should in fact be reduced. No other variables should be needed to explain investment because all the expectations about

future revenue are in the share price, in an efficient market, while desired investment is assumed to be financed in a perfect capital market without credit constraints. In practice there would remain costs of adjustment meaning that equation [5] is an equilibrium that would be adjusted to gradually.

1.3.2. Empirical work on Q and user cost

1.3.2.1. Macro equations using Q alone. Empirical work including Q alone in an investment function at macro level have generally been disappointing, for example Oliner *et al.* (1995) found Q in the United States wrongly signed, and Robertson and Wright (2002) found it insignificant. Papers reviewed in the survey by Caballero (1999) report similar results.

In the words of Altissimo *et al.* (2005), and in contrast to the wealth effect on consumption, "in general empirical evidence linking share prices and investment is limited".[10] They suggest that this is due, first, to the fact that when share prices are low, firms substitute debt for equity due to cost, while when share prices are high, firms use equity issues for restructuring and mergers rather than investment. Second, as for consumption, investment's response may depend on the source of the change in share prices, and whether it is seen as temporary or permanent (Section 1.3.2.3). If markets are inefficient, then the possibility of errors by investors (speculation, fads, bubbles, etc.) cannot be ruled out and firms may justifiably ignore the signal to invest. They may rather focus in indicators such as output or sales. Third, it is at times hard to disentangle the cost of capital channel from the financial accelerator/balance sheet channel as discussed below (Section 1.3.3). There are particular difficulties in using Q to forecast, centred on the need to project equity prices forward.

Most studies in this field are focused on the firm's marginal conditions for optimisation as set out above. On the other hand, developing from Lettau and Ludvigson (2002), Price and Schleicher (2006) for the United Kingdom instead utilised a standard linearised present value asset price decomposition, where the value of the firm is the discounted present value of future profits. This approach does not require marginal Q. Testing outside the sample, they found that Q can not only predict investment over the medium to long term, but also debt accumulation and stock returns.

1.3.2.2. Macro studies using Q with other variables. Successful macro studies have typically included other variables in the investment function. This suggests that Q alone is either mis-measured or not a sufficient statistic for investment.

For example, Cuthbertson and Gasparro (1995) for the United Kingdom established a role for average Q along with the capital gearing ratio (financial accelerator) as well as output (simple accelerator) in determining manufacturing investment over 1968-90. Assarsson *et al.* (2004) for Sweden similarly found that Q is a significant determinant of investment in aggregate Swedish manufacturing over 1951-95 when one includes real output and capital gearing. They also found that the ratio of the equity price index to the deflator for fixed investment is a useful proxy for Q, particularly for forecasting.

There are rather few international studies. An early example was Sensenbrenner (1991) who found that Q was a significant determinant of aggregate investment when using an ARMA-based dynamic specification, where lags of Q were used to proxy for expected future Q's, in the G7 excluding Italy. In an error correction model of investment in the G7, Ashworth and Davis (2001) found a role for the long-run effect of Tobin's Q for Japan

and France only. The specification included other financial variables, namely user cost, as well as lagged investment and output growth, although user cost was not significant.

In a panel study discussed further in Section 1.3.7, Davis and Stone (2004) found that Q was significant on average for 19 OECD countries, with a 1% rise in Q leading to a 1.1% rise in the level of investment in the long term, again in the context of an equation featuring output and real interest rates as a proxy for the cost of capital.

1.3.2.3. Studies distinguishing temporary and permanent changes in share prices.

Following the insight that share price changes may be temporary, Bond and Cummins (2001) sought to measure average Q in the United States using analysts' forecasts rather than share prices, and found the measure was superior, suggesting this is why share prices do not predict investment. Median analysts' forecasts are held to show better the fundamental or permanent component of share prices that may influence entrepreneurs seeking to boost the capital stock. Anderson and Subbaraman (1996) in Australia similarly sought to divide the fundamental and speculative components of share prices and again found only the former has an impact on investment.

In seeming contrast with these results, evidence for the United States also suggests that the stock market bubble of the late 1990s boosted corporate investment. Gilchrist, Himmelberg and Huberman, (2004) developed a model in which an increase in the dispersion of investor beliefs under short-selling constraints predicts a rise in stock price above its fundamental value, or bubble. The model predicts that managers respond to bubbles by issuing new equity and increasing capital expenditure. They tested these predictions (among others) using the variance of analysts' earnings forecasts – a proxy for the dispersion of investor beliefs – to identify the "bubble" component in Tobin's Q. When comparing firms traded on the NYSE *versus* the NASDAQ, they found that the model captures key features of the 1990's technology boom. They provided further evidence in favour of the model using a panel-data VAR framework, and found that shocks to dispersion have positive and statistically significant effects on Tobin's Q, net equity issuance, and real investment.

As for Gilchrist, Himmelberg and Huberman, (*ibid.*), Goyal and Yamada (2004) for Japan found that speculative aspects of share prices affect investment in bubbles, but the fundamental component is crucial in busts. They also found that bank-dependent firms in Japan react to share prices more strongly than those with access to other sources of funds, consistent with the work of Audretsch and Elston (2002) for Germany.

These results can be reconciled by different impacts of measured Q during bubble and non-bubble periods, where the former are quite rare and well-defined (mainly occurring in the United States in the 1990s and Japan in the 1980s). Furthermore, during bubble periods median analyst forecasts may themselves be subject to "euphoria", and hence biased upwards compared with fundamentals. So the median as well as the dispersion may be affected by the bubble. These results may also collectively help to explain the poor results for aggregate Q equations highlighted in Section 1.3.2.1-2.

1.3.2.4. Micro studies. Regarding micro studies, in line with the macro results, these have typically found a need to focus on additional variables besides Q. For example, Alonso and Bentolila (1992) found internal finance or cash flow as well as Q influenced capital investment by Spanish industrial companies. This result was thought to be related to the low level of development of Spanish equity markets at the time. Van Ees and Garretsen (1994) for the Netherlands found that once sales and financial variables are included, the

effect of Q on investment by a panel of companies is low. Audretsch and Elston (2002) estimated a Q equation for German firms where financial constraints also entered the specification. They found Q to be significant for the smallest firms (who have less access to external finance) and second largest firms.

Jovanovic and Rousseau (2009) showed that investment of US firms responds asymmetrically to Q. Investment of established firms, what they call "intensive" investment, was found to react negatively to Q whereas investment of new firms, "extensive" investment, responds positively and elastically to Q. They suggested that this asymmetry reflects a difference in the cost of adopting new technologies. A fall in the compatibility of new capital with old capital raises measured Q but reduces the incentive of established firms to invest. New firms do not face such compatibility costs and step up their investment in response to the rise in Q.

These studies, notably those for the United States and Germany may also help explain the poor results for macro studies because firms behave differently with respect to Q. This is likely to distort its impact at the macro level, particularly over time as the distribution of firms' changes. Multivariate studies including Q may indeed be capturing the investment responses of different groups of firms with each variable.

1.3.2.5. Q and housing investment. Whereas most studies look at non-residential investment, Jud and Winkler (2003) present estimates of a Q model of housing investment, using quarterly data for the United States. The empirical model is estimated using building permits, housing starts, and housing investment as measures of investment. The current and lagged values of the Q ratio are found to be positively and significantly associated with housing investment, whichever way investment is measured. The findings suggest that the housing market indeed functions as Tobin has theorised. Housing suppliers appear to respond to the demands of housing consumers, building more new homes when existing home prices are high relative to new home prices.

Berg and Berger (2005) find similar results for Sweden. Over 1993-2003, quarterly data show a high degree of correlation between the Q ratio and the (logarithm of) two different variables for housing investment. An error correction regression model, controlling for structural breaks, indicates also a stable long-run relationship between the log of building starts and the Q ratio between 1993 and 2003 but not between 1981 and 1992 (the boom and bust period that culminated in the Swedish banking crisis). The latter results suggests again that bubbles – and structural change in the financial system – may blur the effects of Q. Barot and Yang (2002) again find Q significant in the long run for the housing market in Sweden and also in the short and long run for the United Kingdom, based on an error correction approach over 1970-98. House prices may be more domestically focused than share prices, and housing investment more homogeneous, explaining the positive results of these studies. On the other hand, Altissimo *et al.* (2005) comment that effects of house prices on housing investment may be country specific and depend on availability of mortgage finance and the link of house prices to construction costs.

1.3.2.6. Studies incorporating the user cost of capital. As regards user cost, the consensus in the 1980s and 1990s was that it was equally weak empirically as Q. But recent evidence suggests otherwise, for example Chirinko *et al.* (2002) who used US panel data and Ellis and Price (2004) in the United Kingdom both found well determined elasticities of around 0.4-0.5. The latter estimated the capital stock and investment separately but

simultaneously in a structural VECM framework. They criticise the bulk of the existing literature for incorporating both of these processes in one equation.

1.3.2.7. Conclusions on Q and user cost. Concluding this section, it is clear that Q has firm theoretical foundations but has often been disappointing in empirical studies. Possible reasons for this are that omitted variables vitiate the estimates, that there are different effects of temporary and permanent share price changes, or between bubble and non-bubble periods, or that there may be asymmetries between types of firms. Also average Q could proxy marginal Q only with a margin of error.

Paradoxically, Q seems to be more consistently effective in housing that in business investment studies. Another promising approach may be to embed Q in a present value rather than optimising framework. User cost has had similarly disappointing results, but studies estimating the capital stock and investment separately have had superior outcomes. One further reason for difficulties with Q is that implicit in studies using Q alone is an assumption of perfect capital markets with no role for capital market imperfections. Other approaches make these imperfections central to their modelling strategies.

1.3.3. Balance sheets and investment

Two more recent developments in the literature suggest that aspects of the financing of investment by firms through borrowing could yield some additional information regarding the determinants of the level of business investment, namely the financial accelerator and the bank lending channel effect. Whereas both of these concepts rely on the effects of asymmetric information on credit rationing of external finance, the former applies to all debt financing, while the latter focuses more closely on the special nature of bank lending.

Broad lending (from banks or bond markets) is constrained by firms' net worth, while bank lending concerns firms that do not have access to capital markets and for which the only source of external finance is bank lending: *e.g.* firms in countries with shallow capital markets and small firms. This has an impact on the real economy via the distribution of firms. Sectors with a larger number of small firms (such as services) are more affected by the bank lending channel. Only the financial accelerator is linked directly to asset prices (since falling asset prices are one way in which net worth may change). While share prices do not affect the bank lending channel directly, they may do indirectly via the effect of share prices on bank balance sheets, making them more or less willing to lend.

Meanwhile, a further strand of the literature focuses on trade credit as a marginal source of external finance when other sources are unavailable. However, empirical studies suggest that this is mainly relevant for inventory investment in OECD countries (see for example, Guariglia and Mateut, 2006; and Bougheas *et al.*, 2008, for the United Kingdom).

1.3.4. The financial accelerator

1.3.4.1. Theoretical motivation. The supply of external debt finance, be it intermediated or not, is problematic, as a consequence of asymmetric information between borrowers and lenders and the inability of lenders to write complete contracts covering borrowers' behaviour in every eventuality. These give rise to the well-known agency problems of the debt contract, linked to adverse selection in advance of lending and moral hazard after the financing has taken place. These effects may vary over time, giving rise to cyclical

changes in credit supply (as suggested by Holmstrom and Tirole, 1997; and Repullo and Suarez, 2000).

Mishkin (1991) suggests that variations in agency costs affecting credit supply may occur, for example, via a decrease in the valuation of assets (*e.g.* a stock market decline provoked by a change in future profit expectations), which lowers collateral values, sharply increasing adverse selection for lenders; rises in interest rates causing adverse selection to increase sharply, provoking a substantial decline in credit availability; and a parallel mechanism operating via the link of net worth to moral hazard. The agency problem is greater when borrowers have low net worth as they have less to lose from default.

Such movements can give rise to a "financial accelerator" or "broad credit channel" effect (Bernanke, Gertler and Gilchrist, 1999). Changes in cash flow or asset prices over the cycle give rise to pro-cyclical feedback effects of agency costs on the cost of external debt finance (both from banks and securities markets) and hence on real corporate expenditure. This will operate, in particular, for borrowers whose net worth is most heavily affected during a recession, and via borrowers whose activities are riskier or harder to monitor. Small firms are examples in each case.

1.3.4.2. Micro studies. Following the insight that credit constraints may be greater for certain types of firm, most work in this area has been micro based. Early empirical tests of the hypothesis for the United States included Bernanke, Gertler and Gilchrist (1996), who showed that after a monetary tightening, the relationship between internal funds and investment becomes stronger for smaller firms than larger firms. Additionally, small firms experience much more pro-cyclical variation in economic activity than do large firms. Oliner and Rudebusch (1996) found similar results. Hu (1999) using individual firm data showed that monetary contractions reduce investment more for highly leveraged firms than for less leveraged ones.

Outside the United States, Vermuelen (2002) applied the financial accelerator approach to Germany, France, Italy and Spain using micro data and showed that weak balance sheets are more important in explaining investment during downturns than strong balance sheets during upturns, while effects of the accelerator are greatest for small firms and in France and Italy. Chatelain *et al.* (2003) used micro datasets for the same countries and found that investment responds to user cost, sales and cash flow movements. Martinez-Carrascal and Fernando (2008) looking at micro data for six euro area countries, found *inter alia* that a high level of debt can lead to balance sheet adjustments in the form of companies deferring or foregoing investment projects, consistent with the financial accelerator. The largest sensitivity of investment to indebtedness was in the Netherlands and Italy, while German firms were least sensitive, possibly due to banking relationships.

At the national level, Von Kalckreuth (2001) estimated investment functions for German firms featuring user costs (price effect), sales (accelerator effect) and cash flow/capital stock (financial effect). He used Bundesbank credit ratings as a regressor and attributed its effect to the financial accelerator. Looking at the United Kingdom, Guariglia (1999) found a significant link from financial variables to inventory investment, which is stronger for firms with weak balance sheets, during periods of recession and when monetary policy is tight.

Some studies have successfully combined financial accelerator variables with Q. Aivazian *et al.* (2005) for Canada found in a Q investment function that leverage (long-term

debt/assets) is negatively related to investment. This negative effect is greater for firms with low growth opportunities, as proxied by a Q below 1.

1.3.4.3. Macro studies. As noted by Altissimo *et al.* (2005), the fact that micro studies show that small firms are most likely to be subject to financial accelerator effects means that macro effects are likely to be difficult to obtain. This is because small firms are likely to be either unquoted or form a trivial part of the aggregate debt-equity ratio.

One exception is the United States, which is unique[11] in having disaggregated flow of funds data between non-corporate and corporate firms, which enables disaggregated studies at a macro level. Using such flow of funds data, Christiano *et al.* (1996) showed that following a monetary policy shock, borrowing of large corporate firms rises for some time, before falling off in the subsequent recession (perhaps because cash flows fall before expenditure can be adjusted). In contrast, the borrowing of small non-corporate firms (whose net worth may be hit by the monetary policy action) is much weaker. Similar work is not feasible in other countries since corporations are generally aggregated in the national balance sheet data.

Nevertheless, Ashworth and Davis (2001) in their study of aggregate investment in the G7 corporate sectors did allow for a broad credit channel by including the corporate debt/equity ratio in a "Jorgensen" investment function featuring the cost of capital and the accelerator. They found evidence that the long-run level of investment is lower when the debt to equity ratio increases in the United States, Canada, the United Kingdom, France and Germany. The size of the effect appeared to be similar in both the North American and European countries, with the exception of Canada where the effect was three times as great as in any other country. A leveraged effect of a recession could also be found for Canada alone. No effects were found in Italy or Japan. Equally Davis and Stone (2004) using a similar specification found that the debt to equity ratio was a significant long-run determinant of investment in a panel of 19 countries. These results suggest that positive outcomes for macro studies remain feasible.

1.3.5. The bank lending channel

1.3.5.1. Theoretical motivation. Whereas the accelerator focuses on total external finance, the bank lending channel focuses more directly on the special nature of such loans, and suggests that after a monetary tightening, bank lending falls relatively more than other types of debt, thus having a separate effect on investment. The bank lending channel emphasises the effects a change in monetary policy has on supply and demand for bank loans and potential asymmetry between the effects of positive and negative monetary shocks on final activity variables.

An increase in the interest rate may result in a worsening in the financial position of banks, which could be caused either by a fall in deposits, as a result of financial losses by the lender in other markets, or a fall in asset prices, in each case leading to a reduction in the supply of credit. Higher interest rates may reduce banks' ability to profit from their short borrowing position and long lending position, again leading to them reducing the supply of credit. Banks are also constrained by the requirements to keep a minimum capital to risk-weighted assets ratio of 8% or greater by international agreement, so if they are close to this ratio they cannot increase their supply of credit without first increasing their capital.

Effects of monetary policy tightening on bank capital help further to rationalise the separate credit channel (Repullo and Suarez, 2000). Equally, a rise in bank share prices may increase their willingness of capacity to lend – and *vice versa* (Altissimo *et al*., 2005).

Whereas the literature on the bank lending channel incorporates a wide range of work on bank characteristics and lending (see for example Ehrmann *et al*. (2001) and its references) as well as the impact of bank loans on corporate investment, the focus here is on the latter for its more direct relevance to the work in hand.

1.3.5.2. Micro studies. Most work on this hypothesis has again typically disaggregated by firm size and is focused on the United States; not all studies have focused on fixed investment. For example, Gertler and Gilchrist (1994) found a larger role for bank credit in explaining inventory fluctuations for small firms than large ones, as well as a larger and speedier impact of monetary policy on small firms' expenditure and borrowing. They attributed these patterns to the credit channel, interacting with the high costs faced by small firms in switching sources of credit. Gertler and Gilchrist (1992) observed a perverse increase in loans for large companies following a monetary tightening, while there is an immediate reduction for small firms. They attributed this to large firms meeting cash flow shortages by both running down "buffer stock" deposits and increasing loans. With small firms facing higher costs of access to credit, such distress borrowing is not a possibility.

Complementing these results, Kashyap *et al*. (1993) showed that bank-dependent firms lacking bond ratings and with low liquidity are most likely to cut inventories in periods of monetary tightness. Morgan (1994) found sizeable increases in loans made under commitment, likely to be held by larger and stronger borrowers, during periods of tight money. Research by Bernanke (1993) shows that loans made at sizeable spreads relative to the US prime rate, to small and risky firms, shrink as a proportion of total loans as monetary policy becomes restrictive.

Outside the United States, Hoshi *et al*. (1993) have shown for Japan that liquidity is more important for the investment by firms that do not have a main bank link during periods of tight money, and that the credit mix is a significant determinant of investment and inventories. In Germany, the study by Von Kalckreuth (2001) shows that financially constrained German firms (sorted by unfavourable Bundesbank credit ratings) exhibit increased sensitivity to internal funds and decreased sensitivity to user cost. However, there is no distinction between small and large firms, suggesting that at least up to 1997 German relationship banking did not discriminate against the latter. Valderrama (2001) found that in Austria investment of firms with close banking relationships and access to trade credit was less vulnerable to changes in corporate liquidity than is otherwise the case. Butzen *et al*. (2001) for Belgium found that the credit channel as proxied by the impact of the cash flow-capital ratio is larger for smaller firms and those in manufacturing.

1.3.5.3. Macro studies. Aggregate evidence is again quite scanty, which as for the credit channel would be anticipated given the effect is more important for small firms. Looking at the G7, including the bank loans to total debt ratio as a proxy for the bank credit channel, Ashworth and Davis (2001) found significant evidence of a long-run negative effect in both the United States and Japan, *i.e*. investment is lower when bank loans are a higher proportion of debt. Davis and Stone (2004) found that the loan to debt ratio was a significant long-run determinant of investment in a panel of 19 countries.

1.3.5.4. Conclusions on balance sheet effects. Both the credit channel and the financial accelerator are usefully dealt with together since there are strong parallels in the patterns

of empirical work. Generally work has been dominated by micro studies, given the insight that vulnerability to credit rationing due to these channels is itself dependent on firms' characteristics. It is also likely to vary strongly between countries, with respect for example to the closeness of banking relationships (which may itself vary over time). Because of the differing behaviour at the micro level, there have been few attempts to capture these effects using macro data, although the results of the few existing studies are quite promising. A challenge is to further integrate the insights of these areas of work with that on Q, which as noted often assumes perfect capital markets.

1.3.6. Volatility of asset prices and investment

1.3.6.1. Theoretical considerations. According to Dixit and Pindyck (1994), the effect of uncertainty on investment stems from the option characteristics of an investment project, given the option of delaying the project and its irreversibility once begun, together with the uncertainty over future prices that will determine its profitability. The value of the option stems from the fact that delaying the project may give a more accurate view of market conditions. The call option implies a difference between the net present value (NPV) of an investment and its current worth to the investor. To lead to expenditure, the NPV has to exceed zero so as to cover the option value of waiting. The expectation is that heightened uncertainty, by leading to delay in projects, would lead to a fall in aggregate investment. There may also be threshold effects, *i.e.* rates of return below which investment is not undertaken, depending on investors' risk aversion. Abel *et al.* (1996) extended this theory of irreversibility to show that there could be both a call and put option feature in investment, in terms of options to expand or contract the capital stock in the future.

On the other hand, the literature is not unanimous in suggesting a negative effect of uncertainty on investment. Hartman (1972) and Abel (1983) show counter to the above that where there is perfect competition and constant returns to scale as well as symmetric adjustment costs, an increase in uncertainty may also raise the value of a marginal unit of capital and hence the incentive to invest. Lee and Shin (2001) argue that the balance between the positive and negative effects of uncertainty may depend on the labour share of firms' costs.

1.3.6.2. The choice of variable measuring uncertainty. Carruth *et al.* (2000) in a key survey paper suggested there is a broad consensus that the effect of uncertainty on aggregate investment is negative. This holds for a range of indicators, for which there are diverse theoretical considerations. Looking for example at share price volatility, it is argued in Carruth *et al.* (*ibid*) that the use of stock market based measures may reveal cash flow uncertainty for the firm, but are not relevant indicators of future economic shocks and policy changes. Moreover, stock prices may be vulnerable to bubbles rather than reflecting fundamentals. Hence they argue that macroeconomic variables such as price, output and exchange rate volatility are theoretically preferable.

Byrne and Davis (2005*a*) query this approach, since share prices take into account all information relevant to the future profitability of the firm (or at a macro level the corporate sector). Furthermore, one can argue that investment is discounted by the long-term interest rate plus a risk premium, where the latter may be linked to equity market volatility (Davis and Madsen, 2008). Such conflicting views suggest a need to take a comprehensive empirical view of possible measures and their impact.

For example, Byrne and Davis (2005a) assessed the impact of a comprehensive range of potential sources of uncertainty on aggregate business investment across the G7 using Pooled Mean Group Estimation (PMGE) and GARCH methods to model uncertainty. These variables are the CPI, long-term interest rates, nominal and real trade weighted effective exchange rates, industrial production and the stock market index. Volatility of financial rather than real variables was found to be most important. Notably, a significant negative long-run effect from exchange rate volatility was found for the G7 and in poolable subgroups including all four larger EU countries. Volatility of long rates has additionally influenced investment in recent years. For most estimates, a one standard deviation rise in conditional exchange rate volatility leads to a 2-4% fall in investment, although some samples gave greater declines. Meanwhile there were no positive results for industrial production or inflation volatility.[12]

In studying investment by US firms, Bond and Cummins (2004) partly follow the approach of asset price volatility for measuring uncertainty (*i.e.* stock return volatility). But they supplement this by the variance of analysts' forecasts and the variance of forecast errors for such profit forecasts. They find that the latter variables are also highly predictive, with the level of disagreement among analysts providing the most informative uncertainty indicator.

1.3.6.3. Alternative approaches to measuring uncertainty. As regards measurement of uncertainty, in common with Byrne and Davis (2005*a*), Huizinga (1993) and Price (1995) used ARCH or GARCH measures of macroeconomic variables when modelling investment and uncertainty. Huizinga (1993) considered conditional volatility of US inflation, real wages and real profits and generally finds a negative effect on investment at an industry level. Price (1995) utilised the conditional variance of the growth rate of GDP, and finds a negative effect on UK manufacturing investment at the second lag.

The question of whether there is a different effect from forward and backward-looking measures of uncertainty has been raised by Ferderer (1993). He attempts to produce a forward-looking measure based on the risk premium from the term structure. For the United States he finds that the effect on investment is negative. Driver and Moreton (1991) model uncertainty using the standard deviation of 12 months forward predictions of output growth and inflation across 12 forecasting teams. They find a negative long-run effect from output growth on investment but no long-run effect from inflation on investment.

All of these approaches are, in a sense, conditional measures of volatility. Other studies have used unconditional measures, such as Darby *et al.* (1999), who use 8-period moving average variance. Goldberg (1993) and Campa and Goldberg (1995) derived their measure of exchange rate volatility from the standard errors of the residuals from a moving average representation of the exchange rate using US data.

The question of whether unconditional or conditional volatility is most appropriate is an important one. As argued in Byrne and Davis (2005a), the key is the distinction originally due to Knight (1921) between risk and uncertainty. Risk can be defined as the danger that a certain contingency will occur, a measure often related to future events susceptible to being reduced to objective probabilities, while uncertainty is a term applied to expectations of a future event to which probability analysis cannot be applied, such as a change in policy regime or a financial crisis (Shafer, 1986). The response of an uncertain market – and the

response of investment thereto – may appear out of scale with the proximate causes of a given stimulus, if it leads participants to change the way they form their decisions.

In this context, heightened unconditional volatility alone may merely reflect a greater incidence of large random and independent shocks, *i.e.* greater risk, without a change in underlying perceptions as to the situation on the part of firms considering investment.

On the other hand, heightened conditional volatility, besides indicating risk, may also indicate greater (immeasurable) uncertainty on the part of the market regarding the direction of the variable and the intentions of the authorities, including market responses to shocks *per se* (an increased tendency for shocks to have persistent effects on the market) which may be more likely to affect investment. More generally, conditional volatility highlights periods of concentrated volatility which might be expected to maximise uncertainty and hence the option value of waiting to undertake investment, while the rolling measures could just be capturing background volatility with occasional outliers that firms learn to live with. A similar point is made by Serven (2003), who considers use of GARCH essential to measure exchange rate uncertainty as opposed to "sample variability".

1.3.6.4. Studies focusing on exchange rate volatility. A number of studies concur in finding a link from exchange rate volatility to investment. Darby *et al.* (1999) using a model based on Dixit and Pindyck (1994) suggest that there are situations where exchange rate uncertainty will depress investment (*e.g.* when there are perceptions of misalignments) and situations where it will not. In the empirical section of their paper Darby *et al.* (1999) find, using a neoclassical model, Tobin's Q and moving-average unconditional exchange rate variance, that uncertainty has a significant and negative impact on investment for the United States, Germany and France. There are additional dynamic effects which are negative for Italy and the United Kingdom. There are negative misalignment effects for the United States, France, Italy and the United Kingdom.

Serven (2003) using GARCH measures of uncertainty, found a negative and highly significant impact of real exchange rate uncertainty on private investment in a sample of developing countries, after controlling for standard investment determinants. The impact is larger at higher levels of uncertainty – in line with the analytical literature underscoring "threshold effects". Moreover, the effect on investment of real exchange rate uncertainty is shaped by the degree of trade openness and financial development: higher openness and weaker financial systems are associated with a more strongly negative uncertainty-investment link. Openness is often linked to country size, with smaller countries being more open.

Byrne and Davis (2005b) examined the relationship between aggregate investment and exchange-rate uncertainty in the G7, using panel estimation and a decomposition of volatility derived from a Components GARCH model. The dynamic panel approach was considered to take account of potential cross-sectional heterogeneity, which can lead to bias in estimation. They found for a poolable subsample of European countries, that it is the transitory and not the permanent component of volatility which adversely affects investment. To the extent that short-run uncertainty in the Components GARCH model characterises higher frequency shocks generated by volatile short-term capital flows, these are most deleterious for investment. One would expect similar and possibly larger effects on smaller countries.

1.3.6.5. Conclusions on investment and uncertainty. This corpus of work strongly suggests that there is a negative link from uncertainty to investment, and at least for OECD

countries, the volatility of asset prices is the best proxy for such uncertainty. Accordingly, there are numerous results suggesting a negative impact of such asset price volatility. Theoretically, it can be argued that GARCH or other conditional measures of volatility are superior to simple volatility, while a principal focus could justifiably be on exchange rate volatility. Missing from the current literature are disaggregated studies looking at the differing response of small and large firms to asset price volatility, and whether the response interacts in some way with credit market imperfections.[13] Also, there is a question whether the response is linear or whether extreme volatility has a greater impact.

1.3.7. Investment and financial crises

Financial crises can generate additional effects on investment beyond those of traditional variables. They are likely to generate increased uncertainty beyond those indicated by asset price volatility as well as credit rationing beyond that predicted by the financial accelerator or credit channel. Indeed, as shown in Table 1 from Detken and Smets (2004), investment (and inventory contractions) are the main contributors to lower GDP growth after high cost booms, which often feature banking or currency crises at their peak.

Davis and Stone (2004) assessed the impact of crises in both a neoclassical and Tobin's Q specification of investment functions, using dummies to capture the extra impact of financial crises. Their econometric analysis suggests that financial crises have a greater impact on investment expenditure and the financing of corporate sectors in emerging market economies (EMEs) than in OECD countries. OECD countries appear to benefit from a pick-up in bond issuance in the wake of banking crises. Although companies in EMEs hold more precautionary liquidity, this is evidently not sufficient to prevent a stronger response of expenditure to shocks.

2. Estimation of investment functions

In the light of the above, investment functions have been estimated with a view to obtaining new evidence on asset price effects on real non-residential fixed investment. The work is in two parts, following the above, with work being first on effects of levels of asset prices on investment (largely via Tobin's Q and the debt-equity ratio). Then, work on the relation between asset price volatility and investment is undertaken. The work expands earlier work in both fields considerably, by providing results for over 20 OECD countries, and using data up to 2008. This in turn also provides background for an assessment of investment in the recent crisis.

2.1. Data

In all cases, the estimations are based on annual data. This is partly due to the use of annual data for sectoral balance sheets and the capital stock, which are crucial for estimating most of the asset price effects. However, we also contend that annual data ensure that dynamics can be simple and comparable, while it facilitates a focus on the long-run properties of the data.

The sample begins in 1970 for all estimates, which thus excludes the 1960s when a different regime was in force for exchange rates, and both domestic and international financial markets were generally not liberalised. Already by 1971 came the breakdown of Bretton Woods and heightened asset price volatility, as well as growth of international capital markets and progressive liberalisation of domestic ones, benefiting the corporate sector at an early stage. In order to maximise use of available information, all the data

available between 1970 and 2008 are used for each estimate. This does make for different samples, given the restricted availability of flow of funds balance sheet data compared with asset prices and real economy variables. Robustness checks are reported later using the same size and composition of panels for each equation – results are very similar.

The data are almost exclusively from the OECD, which should ensure a high degree of harmonisation. The time period for each data series is given in the Annex. We use real business investment (IB) as our dependent variable. Wider private sector aggregates often include housing investment and the housing stock, which has a different cyclical pattern as business investment. Business-sector data also overcome the problems of transfer from public ownership, by including business-sector investment whatever its ownership. Meanwhile, for measuring real output, real GDP is used. For the cost of capital the real long-term interest rate (deflated by the deflator for GDP, PDGP) is employed, although the OECD's estimate of the user cost of capital and the BBB bond yield was also used. The cost of capital is calculated as the tax-adjusted purchase price of a unit of capital, multiplied by the real post-tax financial cost of capital plus the depreciation rate (Schreyer *et al.*, 2003).

There are arguments favouring other possible deflators for the long rate. Ideally the real interest rate should reflect the prices of goods and services in the domestic economy. The GDP deflator does this quite well but can behave in a counter-intuitive manner in an oil crisis since it includes import prices as a negative item. The investment deflator, PIB, might be seen as closer to the dependent variable but tends to be highly volatile which reduces its usefulness in measuring a real interest rate (which is of course trying to proxy future inflation expectations). There are also arguments for a consumption-based deflator such as the CPI or consumers' expenditure deflator (CED). Besides being commonly focused on by authorities in macro management, they are also close to the desired measure of overall goods and services prices – the deflator for total final expenditure is not so readily available. We consider the choice for our current work to be an empirical matter and find PGDP to be best able to capture the negative effects of the cost of capital on investment, and hence utilise it throughout. Variants are provided in Section 2.5 with alternative measures of the risk free rate using PIB and the CPI.[14]

For estimating effects of levels of asset prices on investment, these data are combined with annual balance-sheet data for the corporate sector, derived from the OECD national accounts database. These include, in particular, data on the three main corporate financial liabilities, namely the stock of equity outstanding at market value, the stock of bonds and the stock of bank loans as well as trade credit. These series are all annual, which further justifies the use of annual data in our estimation. Complementing these we use annual data for the non-financial corporate sector nominal net capital stock, which is obtained from the OECD's STAN database. As a variant, given the limited data on nominal capital stocks, a volume measure of the real net total productive capital stock is also used, which is translated into an estimated nominal value by using the business investment deflator.

For estimating effects of volatility of asset prices on investment, the data above are combined with GARCH estimates of the conditional volatility of exchange rates, share prices and long-term interest rates derived in turn from first differenced monthly underlying data for the same series (in logs for exchange rates and share prices and in levels for interest rates). We also use unconditional measures of volatility as a robustness check. Unconditional variance is measured as the non-overlapping annual variance series

derived from monthly per cent changes in underlying variables. The share price indices came from the IMF's IFS database, the rest from the OECD.

To be concise, details of the GARCH estimates are not provided (full details of conditional variance estimation results are available from the author). It suffices to note here that significant GARCH effects were present in each case and that the GARCH process in the conditional-variance equation was in virtually all cases covariance stationary with $a1 + b1 < 1$. We note, following Engle (1983) that GARCH generates a model-dependent outcome, although the approach adopted, of differencing the conditional-mean equation sufficiently to avoid autocorrelation, is fairly standard.

Table 3 shows the Im-Pesaran-Shin panel unit root tests[15] for the regression variables, which show that logs of investment and GDP have unit roots in levels, as would be expected given these are trended variables. The conditional variances are all stationary, as is the real long rate and user cost of capital. We also anticipate that the logs of financial ratios will be stationary, since they cannot be trended in the long term, but this is not the case for the debt-equity ratio, Tobin's Q or the trade credit/GDP ratio. This is probably due to the short time series that are available. In practice, variables other than investment and GDP are treated as stationary in the estimations, given these are the only variables with a fundamental trend in them.

Table 3. **Panel unit root tests (Im-Pesaran-Shin)**

Data sample 1970-2008	Level		Difference	
Variable	ADF	Prob	ADF	Prob
I	4.8	1.00	–17.5	0.00
Y	0.9	0.81	–16.2	0.00
IRLAR	–2.9	0.00		
ERVAR	–10.7	0.00		
LRVAR	–21.5	0.00		
SPVAR	–10.4	0.00		
LDER	–1.0	0.17	–7.8	0.00
LBANK	–4.8	0.00		
LQ	0.5	0.70	–3.6	0.00
LQE	1.4	0.93	–6.3	0.00
UCC	–2.8	0.00		
LTCY	–1.4	0.08	–7.1	0.00

Note: I = log of real business investment, Y = log of real gross domestic product, IRLAR = long-term interest rate less GDP deflator, ERVAR = annual average conditional volatility of nominal effective exchange rate [derived from GARCH (1,1) equations], LRVAR = annual average conditional volatility of long-term interest rates [derived from GARCH (1,1) equations], SPVAR = annual average conditional volatility of share prices [derived from GARCH (1,1) equations]. LDER log of debt/equity ratio, LBANK log of bank loan/total debt ratio, LQ log of average Q (market value of firms divided by net capital stock at current replacement cost), LQE, log of average Q using an estimate of the capital stock based on multiplying a volume measure of the real net total productive capital stock by the business investment deflator, UCC user cost of capital as defined in Schreyer *et al.* (2003), LTCY log of trade credit as corporate liability/nominal GDP.
Source: OECD, except for share prices – IMF.

2.2. Basic specification

Following the discussion above, in this section a baseline "Jorgensen" investment function is developed which can be extended both for testing the long-run relationship between levels of asset prices and investment and also uncertainty and investment. We follow Bean (1981), Driver and Moreton (1991) and Darby *et al.* (1999) in estimating a dynamic-error correction model of investment including both short and long-run terms in output, investment and the cost of capital. Consistent with these authors, the long-run homogeneity of output as implied by the CES production function is tested. A flexible

accelerator based investment function is used (testing for additional cost of capital effects) by panel estimation with country fixed effects.

The flexible accelerator model is represented by a short and long-run relationship between investment and output, such that a desired output-capital relationship is maintained. This ignores, however, possible substitution effects between factor inputs, unlike the neoclassical model of Jorgensen (1963). To take account of possible substitution effects the neoclassical model incorporates factor prices in the form of the user cost of capital (C_t). Hence as noted above, the desired capital stock (K^*_t) is as follows:

$$K_t^* = \frac{\alpha Y_t}{C_t^\sigma} \quad [6]$$

where Y_t is output, α is a constant and σ is the elasticity of substitution between factor inputs.

As discussed in Carruth *et al.* (2000), empirical investigators typically assume either that net investment is determined as a distributed lag process of changes in the desired capital stock, or that there are explicit costs of adjustment. Then, it is possible to obtain an investment function for empirical estimation that equates the level of investment to lags of the change in the level of output and the user cost of capital, without the need for a capital stock in the final estimation. This is illustrated in the following four equations, where equations [7] and [8] show the evolution of investment in terms of the capital stock, (where δ is the depreciation rate and g is the steady state growth rate), [9] integrates this into the equation [6] and [10] sets out the long-run equation in logarithmic form:

$$I_t = \delta K_t + dK_t \quad [7]$$

$$I_t = (g + \delta)K_t \quad [8]$$

$$I_t = \alpha(g + \delta)Y_t / C_t^\sigma \quad [9]$$

$$\ln(I_t) = \theta_0 + \theta_1 \ln(Y_t) - \varepsilon \ln(C_t) \quad [10]$$

In addition, the dynamics are specified. Following the approach of Cuthbertson and Gasparro (1995), Carruth *et al.* (2000) and Byrne and Davis (2005a and b) to modelling investment, the basic equation is as follows:

$$\Delta \ln(IB)_{it} = \phi_i \left(\ln(IB)_{i,t-1} - \theta_{0i} - \theta_1 \ln(YB)_{it}\right) + \sum_{j=1}^{p} \delta_{ji} \Delta \ln(IB)_{i,t-j} + \sum_{j=0}^{q} \varphi_{ji} \Delta \ln(YB)_{i,t-j} + \varepsilon_{it} \quad [11]$$

where *IB* is business investment and *YB* is GDP, and cost of capital effects are added in the short and long run. The basic equation can also be augmented with Tobin's Q effects as an alternative to the cost of capital (Section 2.3) and other variables of interest affected by the level and volatility of asset prices.

Results of estimation for the full sample are provided in Table 4, where the real long-rate is used to proxy the cost of capital. As can be seen, the specification for all 23 countries has virtually all variables significant. In terms of dynamics, the accelerator term in the growth of GDP is 2.541 and lagged investment growth is also significant with a coefficient of 0.178. The change in the long rate has a correct sign and is significant. Lagged GDP growth is not significant, however.

In terms of the long run, we note first that the log of investment, log of GDP and real long rate are cointegrated according to the Kao and Pedroni panel cointegration tests. The Kao test is preferred, given that Gutierrez (2003) sees Kao as superior to Pedroni for small samples, and that both are superior to the Larsson test. But for completeness the Pedroni v-test is also

Table 4. **Basic investment functions**

Unbalanced panel, 1970-2008	All 23 countries, 778 observations		G7 countries, 273 observations		16 smaller OECD countries, 505 observations	
Variable	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
C	–2.056657	–7.8***	–3.891214	–9.8***	–1.543394	–4.6***
DY	2.541518	22.0***	2.126941	16.5***	2.734334	17.5***
DY(–1)	0.054222	0.4	0.406774	2.3**	0.024486	0.1
DI(–1)	0.178643	5.1***	0.222612	4.3***	0.157090	3.5***
I(–1)	–0.148396	–9.7***	–0.211946	–8.9***	–0.142468	–7.4***
Y(–1)	0.207078	10.1***	0.325019	9.9***	0.184625	7.3***
DIRLAR	–0.001482	–2.2**	–0.002243	–2.0**	–0.001381	–1.6*
IRLAR(–1)	–0.001396	–2.2**	–0.002243	–2.5**	–0.001425	–1.7*
Adjusted R-squared	0.477094		0.632913		0.460599	
S.E. of regression	0.063732		0.035849		0.073694	
Sum squared residual	3.038240		0.332845		2.617617	
Log likelihood	1 053.245		528.4832		612.1653	
Long-run income effect	1.395442		1.533499		1.295905	
Long-run long rate	–0.00941		–0.01058		–0.01	
Memo:	Statistic	Prob	Statistic	Prob	Statistic	Prob
Kao panel cointegration+	–5.71	0.00	–3.66	0.00	–4.07	0.00
Pedroni v-test+	3.07	0.00	1.63	0.11	2.58	0.01
Memo: using UCC instead of IRLAR	18 countries, 394 observations		7 countries, 163 observations		11 countries, 231 observations	
DUCC	–0.027569	–0.1	1.537335	3.2***	–0.724605	–1.4
UCC(–1)	–0.325360	–1.4	–0.100614	–0.4	–0.366292	–1.1

Note: I = log of real business investment, Y = log of real gross domestic product, IRLAR = long-term interest rate less GDP deflator, UCC user cost of capital as defined in Schreyer *et al.* (2003), D is the difference operator. * indicates significance at 90%, ** at 95% and *** at 99%. + tests for cointegration of I, Y and IRLAR.

included. The error correction term on lagged investment can be used to derive long-run values, also shown in the table (the long-run effect is minus the coefficient on the lagged level terms divided by the error-correction coefficient). As in Byrne and Davis (2005a and b) there is no evidence of long-run homogeneity of investment and output, with the implicit output coefficient being 1.395, more than 2 standard errors away from 1.[16] The error correction term is –0.148, implying quite slow adjustment from disequilibria. Meanwhile, the long-run real rate term is again not significant, with a long run effect of –0.0094, close to unity bearing in mind the long rate is in levels and the rest of the equation in logs.

In this and other estimates, two subcategories, the G7 countries and the smaller OECD countries, are distinguished. This can be justified by their openness, relative dominance by multinational enterprises and resulting different vulnerability to external shocks, as well as typical degree of monetary policy autonomy (since small countries often target exchange rates while G7 ones have more scope for floating). In the G7, the main distinction from the full sample is that the lagged income growth term is also significant. The accelerator is smaller at 2.127. The long-run income coefficient is 1.533, with again no evidence for homogeneity. Furthermore, the error correction term is higher at 0.212, implying more rapid adjustment to equilibrium. In contrast, for the smaller countries, there is no lagged output effect detectable, while there is a larger accelerator term (2.734), slower error correction adjustment and again no long-run homogeneity. The real long rate

is only significant at 90% for the smaller countries, but consistently has a correct sign in levels and differences, and close to unit long run elasticity.

As an alternative, a specification using the OECD measure of the user cost of capital was tested, as set out in Schreyer *et al.* (2003) instead of the real long rate. The results are shown at the bottom of Table 4. Because of short time series, the samples are much smaller. The variable is not significant except for the difference term for the G7, which has the wrong sign. A further test was with real BBB bond yields, which have very limited data (only 102 observations for the full sample). Although this is more appropriate for firms than the risk-free long rate, probably due to the short samples, the level and difference are insignificant in all cases. Accordingly, the real long rate is retained as the cost of capital term for the rest of the work reported here.

This specification was used as a test bed for asset price effects on investment, bearing in mind that the long rate itself is a form of asset price determined by supply and demand for government bonds. Owing to data limitations, the level estimations often have less observations and countries than the results shown in Table 4. In contrast, owing to the availability of long time series for monthly data for exchange rates, share prices and long rates, the variance results in Section 2.4 are more comparable in country and time coverage. Some standardised samples are reported in Section 2.5, which have similar patterns to those reported here, however.

2.3. Levels of asset prices and investment

In line with Ashworth and Davis (2001) and Davis and Stone (2004) the basic "Jorgensen" style equation is augmented with variables reflecting the balance sheet and cost of capital effects discussed in Sections 1.3.2 to 1.3.4. Accordingly, we incorporated one at a time the log of the corporate debt-equity ratio to allow for the financial accelerator, the log of the bank lending to total debt ratio to capture the credit channel, and finally Tobin's Q (as a substitute for the real long rate) as an alternative cost of capital term. Q is determined using respectively data for the nominal net capital stock (as is theoretically correct) but also using an estimate of the nominal capital stock derived from real productive capital and the business investment deflator. The latter is likely to be less accurate, but has a longer time series. A variable for trade credit is also assessed, the log of trade credit as a proportion of GDP, while noting that existing empirical work does not tend to support an effect of trade credit on fixed investment (as opposed to inventories) in advanced countries.

As specified above, the debt-equity ratio and also Tobin's Q directly capture the effect of equity prices on corporate investment, whereby in both cases a positive relationship is expected. In contrast, the credit channel does not explicitly include equity prices but may be affected indirectly if falls in bank share prices affect their willingness to lend. Trade credit is not directly related to asset prices. A Q effect, leaving out all other investment determinants, is also assessed.

Concerning the financial accelerator and the credit channel, data covering 20 countries but only around 300 observations over 1970-2008 exist as opposed to over 800 in the basic equation. The OECD balance-sheet data for most countries begin only in the 1990s (see Annex), although the US data begin in 1960 and Canada in 1970. As shown in Table 5, in general, certain results are positive for both the financial accelerator and the credit channel for this group of countries. The debt-equity ratio (LDER) is significant for

Table 5. **Significance of financial variables in basic investment functions**

Unbalanced panel, 1970-2008	All countries		G7 countries		Smaller OECD countries	
Variable	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
	20 countries, 337 observations		7 countries, 168 observations		13 countries, 169 observations	
LDER(–1)	–0.011602	–1.2	–0.023861	–1.9*	–0.000554	0.1
Long-run effect	–0.03654		–0.07597		–0.00168	
	20 countries, 337 observations		7 countries, 168 observations		13 countries, 169 observations	
LBANK(–1)	0.092239	2.0**	0.089260	1.6*	0.107165	0.9
Long-run effect	0.288351		0.288685		0.324916	
	13 countries, 176 observations		6 countries, 98 observations		7 countries, 78 observations	
DLQ+	0.013604	0.6	0.059430	2.0**	–0.050614	–1.4
LQ(–1)+	0.013038	0.8	0.043097	2.1**	–0.025515	–0.9
Long-run effect	0.039		0.147		–0.066	
	17 countries, 239 observations		7 countries, 122 observations		10 countries, 117 observations	
DLQE+	0.012903	0.7	0.058001	2.5**	–0.029490	–1.2
LQE(–1)+	0.003230	0.3	0.039480	2.2**	–0.033912	–1.7*
Long-run effect	0.011		0.122		–0.121	
	16 countries, 233 observations		7 countries, 152 observations		10 countries, 101 observations	
LTCY(–1)	–0.0051	0.3	0.031479	1.4	–0.025967	1.1
Long-run effect	–0.01512		0.101327		–0.05474	

Note: Basic equations as in Table 4. LDER log of debt/equity ratio, LBANK log of bank loan/total debt ratio, LQ log of average Q (market value of firms divided by net capital stock at current replacement cost), LQE, log of average Q using an estimate of the capital stock based on multiplying a volume measure of the real net total productive capital stock by the business investment deflator, D is the difference operator. +Q is included in levels and differences as a substitute for the real interest rate in Table 4.
* indicates significance at 90%, ** at 95% and *** at 99%.

the G7 at 90%, albeit not for the smaller OECD countries or for the full group of countries. Since there are fixed effects, we are not merely capturing cross-country differences. The bank lending to total debt ratio (LBANK) is significant for both the G7 (at 90%) and the full group of countries. The trade credit to GDP variable (LTCY) is insignificant, confirming that there is not an important role for trade credit in fixed investment determination.

Tobin's Q is entered in levels and differences. Using the "correct measure" of Q, we suffer from a lack of data for the nominal net capital stock, which even more severely limits the observations that can be used, as well as the country coverage, to 13 countries and around 170 observations. The incorporation of average Q into the basic investment function as a substitute for the real long-term interest rate is successful for the G7, with the variable being significant even in the presence of the accelerator (growth of GDP) term. This is not the case for the total and smaller country groups where Q is not significant, perhaps reflecting less well-developed equity markets. The "estimate" of Q (LQE) has more observations but broadly identical results, except that it is significant in levels for the smaller countries also, at the 90% level.

However, as shown in Table 6, if only Q is included in a dynamic equation with lagged investment (as is theoretically justified) it becomes significant in both the short and long run for all the country groups (albeit with a low level of overall explanation for the equation). Whereas the short-run effect of Q is 0.107, the long-run elasticity with respect to

Table 6. **Simple Q equations**

Unbalanced panel, 1970-2008	All countries, 13 countries, 176 observations		G7 countries, 6 countries, 98 observations		Smaller OECD countries,7 countries, 78 observations	
Variable	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
C	1.480571	2.7***	1.272885	2.2**	2.277080	1.5
DLQ	0.107163	3.2***	0.099577	2.2**	0.109916	2.1**
LQ(–1)	0.077960	3.3***	0.103734	3.3***	0.064511	1.6*
I(–1)	–0.058240	–2.7***	–0.058719	–2.6**	–0.083352	–1.5
Adjusted R-squared	0.051355		0.098221		–0.002500	
S.E. of regression	0.061379		0.057833		0.066005	
Sum squared residual	0.602775		0.297677		0.296249	
Log likelihood	249.8160		144.9830		106.6800	
Long-run effect of LQ	1.33		1.77		0.774	
Memo: with LQE	17 countries, 239 observations		7 countries, 122 observations		10 countries, 117 observations	
DLQE	0.117614	4.7***	0.135144	4.0***	0.092603	2.6**
LQE(–1)	0.099472	5.7***	0.159640	7.0***	0.039573	1.5
I(–1)	–0.116273	–4.6***	–0.171977	–5.8***	–0.042642	–1.0
Long-run effect of LQE	0.855		0.928		0.928	

Note: I = log of real business investment, LQE, log of average Q using an estimate of the capital stock based on multiplying a volume measure of the real net total productive capital stock by the business investment deflator, D is the difference operator.
* indicates significance at 90%, ** at 95% and *** at 99%.

investment is 1.33 for the full group of countries, and 1.77 for the G7, with 0.774 for the smaller countries. There are similar results for the estimated LQE variable. In practice, the estimates of long-run Q are often not significantly different from 1, as is theoretically expected, while Wald tests showed that the long-run coefficients are insignificantly different from one another in the four EU countries, and are close to being identical across the whole G7. This result is a major contrast to work cited in the literature surveys by Oliner *et al.* (1995), Robertson and Wright (2002) and papers reviewed in the survey by Caballero (1999). It may be that the error correction framework for Q helps generate such positive results, with firms overcoming financial constraints to desired investment in the long run.

Overall, these results indicate that Q remains worthy of monitoring by policymakers, and in combination with the result for the debt-equity ratio, it was shown that equity prices are important determinants of investment, notably in the G7. The positive results for the bank lending/total debt channel again favour monitoring this variable, as does the debt/equity ratio for the G7.

The insignificant results for balance-sheet effects in smaller countries are noteworthy, and it was assessed whether they result from a few outliers with poor data that could be dropped and all of the errors in excess of two equation standard errors were dummied out (not shown in detail). Unfortunately there was no improvement in the significance of the variables in question, either for the debt-equity ratio, the share of bank lending or Q. Also pooled-mean-group estimators were used (not reported in detail) to see whether allowing for heterogeneous dynamics would allow for significant long-run balance sheet effects in the smaller countries, but the result of insignificance remained. Possible reasons for the poor results for the smaller countries, besides data quality and short data periods, could include close banking relationships that overcome credit constraints, or heterogeneous corporate sectors where equity markets and hence related macro indicators are dominated

by large globally active firms such as Nokia. If there is little or no corporate bond market activity, as is often the case in small countries, the credit channel effect will be hard to identify at a macro level. Finally, the relatively poor results for balance sheet variables could reflect the short sample, notably for small countries (see Annex); as shown in Table 3 only the bank lending variable is I(0), even for the whole sample, while the others are I(1). Since I, Y and IRLAR cointegrate, other I(1) variables may end up excluded.

2.4. Volatility of asset prices and investment

Turning to effects of asset price volatility, the annual average conditional volatility of nominal effective exchange rates, long rates and share prices were entered into the basic equations set out in Section 2.2 and shown in Table 4. In line with the error-correction specification, both the difference and lagged level of these proxies for uncertainty were entered. Because of extreme volatility in Mexico during the hyperinflation of the 1980s, that country was omitted from the estimation.

As shown in Table 7 (Panel A), a marked difference between the G7 and the smaller OECD countries was found, in that the uncertainty variables tend to be highly significant for the smaller countries (and accordingly the full sample) but not the G7. Across the whole sample, there is a significant positive effect of both exchange rate and long-rate volatility both in the short and the long run. There is also a significant effect of share price volatility in the short run.

For the smaller countries a similar pattern is found, except the share price volatility term is significant only at 90%, while there is no short-term effect of exchange rate volatility. However, the pattern does not hold for the G7 where all of the volatility terms are insignificant, in contrast to Byrne and Davis (2005a). It was also tried omitting the cost of capital terms as well as estimating by pooled-mean-group, but the result of insignificance

Table 7. **Significance of financial asset-price volatility in basic investment functions**

Panel A. Conditional volatility

Unbalanced panel, 1970-2008	All countries (excluding Mexico), 22 countries, 749 observations		G7 countries, 7 countries, 266 observations		Smaller OECD countries (excluding Mexico)	
Variable	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
DERVAR	–18.73541	–2.2**	–7.426388	–0.4	–15.26938	–1.4
ERVAR(–1)	–42.02803	–3.6***	4.376449	0.2	–50.02430	–3.4***
Long-run effect	–298.832		20.48861		–375.716	
	22 countries, 731 observations		7 countries, 273 observations		15 countries, 458 observations	
DSPVAR	–0.696092	–2.0**	–1.566338	–1.1	–0.665184	–1.6*
SPVAR(–1)	–0.643844	–1.4	–2.392385	–1.3	–0.591834	–1.1
Long-run effect	–4.33828		–11.3185		–4.06312	
	22 countries, 763 observations		7 countries, 273 observations		15 countries, 490 observations	
DLRVAR	–0.029047	–5.5***	0.025698	0.8	–0.030601	–5.0***
LRVAR(–1)	–0.023799	–3.4***	0.032289	1.3	–0.026842	–3.2***
Long-run effect	–0.16538		0.152626		–0.19378	

Note: Basic equations as in Table 4. ERVAR = annual average conditional volatility of nominal effective exchange rate [derived from GARCH (1,1) equations]; LRVAR = annual average conditional volatility of long term interest rates [derived from GARCH (1,1) equations]; SPVAR = annual average conditional volatility of share prices (derived from GARCH (1,1) equations]. D is the difference operator. Conditional volatility is the variance series derived from GARCH (1,1) estimates. * indicates significance at 90%, ** at 95% and *** at 99%.

Table 7. **Significance of financial asset-price volatility in basic investment functions** *(cont.)*

Panel B. Unconditional volatility

Unbalanced panel, 1970-2008	All countries (excluding Mexico), 22 countries, 733 observations		G7 countries, 7 countries, 259 observations		Smaller OECD countries (excluding Mexico), 15 countries, 474 observations	
Variable	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
DEERUV	–11.16270	–2.1**	–1.196374	–0.1	–11.18723	–1.7*
EERUV(–1)	–18.79882	–2.7***	–15.81590	–1.2	–17.01811	–2.0**
Long-run effect	–126.165		–69.1221		–119.067	
	22 countries, 727 observations		7 countries, 273 observations		15 countries, 454 observations	
DSPUV	–0.970486	–2.8***	–0.817787	–0.9	–0.943368	–2.3**
SPUV(–1)	–0.855200	–1.6*	–1.386076	–1.2	–0.763722	–1.2
Long-run effect	–5.605		–6.56553		–5.10015	
	22 countries, 759 observations		7 countries, 273 observations		15 countries, 486 observations	
DLRUV	–0.026593	–2.8***	0.027456	1.3	–0.032883	–2.9***
LRUV(–1)	–0.032687	–3.0***	0.039503	1.7*	–0.041459	–3.1***
Long-run effect	–0.22304		0.187275		–0.2941	

Note: Basic equations as in Table 4. ERUV = annual average unconditional volatility of nominal effective exchange rate, LRUV = annual average unconditional volatility of long-term interest rates; SPUV = annual average unconditional volatility of share prices. Unconditional variance is the non-overlapping annual variance series derived from monthly per cent changes in underlying variables. D is the difference operator. * indicates significance at 90%, ** at 95% and *** at 99%.

Table 7. **Significance of financial asset-price volatility in basic investment functions** *(cont.)*

Panel C. Cubed conditional volatility

Unbalanced panel, 1970-2008	All countries (excluding Mexico), 22 countries, 749 observations		G7 countries, 7 countries, 266 observations		Smaller OECD countries (excluding Mexico), 15 countries, 483 observations	
Variable	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
DERVAR	–24.23693	–2.8***	–7.542809	–0.4	–22.80927	–2.1**
ERVAR(–1)	8.971590	0.5	4.803911	0.2	9.414866	0.4
ERVAR(–1)**3	–7 021 745.0	–4.4***	–425 171.5	–0.1	–7 048 557.0	–3.4***
	22 countries, 717 observations		7 countries, 266 observations		15 countries, 454 observations	
DSPVAR	–0.578144	–1.7*	–0.619708	–0.4	–0.555293	–1.4
SPVAR(–1)	–1.316159	–1.8*	–4.616102	–2.0**	–1.169841	–1.3
SPVAR(–1)**3	70.39422	1.2	17 320.24	1.7*	58.13668	0.8
	22 countries, 749 observations		7 countries, 266 observations		15 countries, 486 observations	
DLRVAR	–0.028610	–5.5***	–0.003118	–0.1	–0.030016	–4.9***
LRVAR(–1)	–0.003768	–0.3	–0.008427	–0.2	–0.007388	–0.5
LRVAR(–1)**3	–0.000242	–1.0	0.006279	0.1	–0.000228	–1.6*

Note: Basic equations as in Table 4. ERVAR = annual average conditional volatility of nominal effective exchange rate [derived from GARCH (1,1) equations]; LRVAR = annual average conditional volatility of long-term interest rates [derived from GARCH (1,1) equations]; SPVAR = annual average conditional volatility of share prices [derived from GARCH (1,1) equations]. D is the difference operator. * indicates significance at 90%, ** at 95% and *** at 99%.

for the G7 remains robust. Possible explanations could be that markets in these countries tend to be less volatile owing to a wider range of participants and hence liquidity. The time period of estimation differs from Byrne and Davis (2005a), being longer here. Also large countries are less vulnerable to currency crises and tensions than smaller countries.

A further point may be that derivatives markets are better developed in larger countries, enabling firms to better protect their cash flows against asset-price volatility. The result is consistent with that of Serven (2003) cited in Section 1.3.6, who found trade openness to be a key indicator of vulnerability of investment to uncertainty.

Following the arguments cited in Section 1.3.6.3, conditional volatility measures are considered to be superior to unconditional volatility, and that the GARCH based measure offers more of the theoretical characteristics of uncertainty than an unconditional measure would. On the other hand there can also be arguments favouring unconditional volatility, such as the possibility of omitted variables from the mean and conditional variance equation in GARCH (1,1) and that some contend financial markets are better modelled with non-linear GARCH models. Accordingly, and also as a robustness check, results for unconditional volatility are reported, namely the non-overlapping annual variance series derived from monthly per cent changes in underlying variables. As shown in Table 7 (Panel B), the results are consistent with the same pattern of overall results, namely significant results for a negative effect of uncertainty in the overall sample, apparently driven by the smaller countries. We now obtain long-run effects of share price volatility across the whole sample, at 90% significance. And there is a wrong-signed long-run effect of long rate volatility for the G7.

A further experiment was to test for non-linear effects of uncertainty by introducing cubed-variance terms as well as levels of variance. As suggested by Serven (2003) there may be threshold effects on investment that only operate at high levels of volatility. The outcome is shown in Table 7 (Panel C). As can be seen, for the exchange rate in all countries and the smaller ones, the cubed term is significant and renders the lagged levels term insignificant. This strongly suggests that it is extreme exchange rate volatility, *e.g.* during a currency crisis, which is most damaging to investment.

A similar effect obtains for the cubed effect of long rate-volatility for the small countries, at 90% significance. Extreme long-rate volatility may accompany a currency or fiscal crisis. It displaces the long-run level effect shown in Table 7 (Panel A).

Finally for share prices it is the level of variance and not the cubic term that is significant for all countries. In the G7 there are opposing effects, both significant at 90%, with the level having a negative sign and the cube is positive. All share-price terms are insignificant for the smaller countries. So the extreme volatility effect does not seem to be present for share prices in the same way.

2.5. Further robustness checks and variants

Whereas in the above results we used all available data, to check robustness we first restricted the sample for all estimates to a standardised sample, namely that of the basic flow of funds balance-sheet variables. This means three countries are omitted and for many countries observations exist only from 1995-2007, while the uncertainty and basic equations have smaller samples. As shown in Davis (2010), results were very similar to the basic equations, underlining the robustness of the specification. Meanwhile the conditional volatility estimates (again reported in Davis 2010) lose their significance for the share price and exchange rates for all countries, and although the long rate effect remains, it has the wrong sign. In the smaller countries, there remain only significant difference terms for exchange rate and long rate volatility. This shift may result from the omission of the volatility of the early 1990s as well as in the 1970s and 1980s from the small country

sample. These were driving the strongly significant negative effects of volatility in the smaller countries, while by finishing the sample in 2007 the economic and financial crisis is also omitted. The longer samples reported in Table 7A are more relevant, in our view.

Using the main results sample, it was further checked whether outliers are a major problem, notably for the smaller countries. Dummies for each residual in excess of two equation standard errors were created and the basic equation (Table 4) was run for all countries and the smaller ones, as well as the uncertainty results for the smaller countries. The basic equation was little affected by the dummies, but interestingly the uncertainty results became much weaker. This shows again that it is the extreme observations that generate much of the significance of the uncertainty effect on investment in those countries.

Alternative deflators for the long real rate in the basic equations were assessed to see whether the results could be improved with the deflator for business investment (PIB) or the consumer price index (CPI) instead of PGDP in calculating the real interest rate. Note that the user-cost estimate cannot be changed, as it is a pre-defined variable. In terms of the basic equation, Davis (2010) shows that each of the alternatives is statistically inferior. Accordingly, PGDP was retained in the real rate for the basic results.

Structural change over the sample in the basic equations was tested by incorporating leveraged coefficients in the equations. In other words, the variables were multiplied by a dummy which is 1 from 1995 onwards and 0 earlier on. The rationale for this date is that the internet was becoming generally used and computers and associated hardware a much greater component of aggregate investment. Accordingly, there might have been changes in the relationship of investment to its determinants in the short and long run. In fact, as shown in Davis (2010) there are some significant changes but these are solely in the dynamics, with the long-run coefficients being unchanged at 95%. This is seen as a justification to continue with the long sample wherever feasible, particularly since the main focus is on the long-run results.[17]

2.6. Tracing the recent history of fixed investment

In the light of the above, as well as the financial crisis of 2008-09, we considered the behaviour of investment since 2007:Q3 and looked at its determinants over 2006-08. Bear in mind that the financial crisis began in August 2007 with the advent of credit rationing in the interbank market, but was sharply aggravated in September 2008 when Lehmans failed (Barrell and Davis 2008). Table 8 reveals that OECD countries have faced differing patterns of investment over this period. For most countries, investment continued to rise until 2008:Q2, despite the advent of banking difficulties in 2007:Q3. The exceptions are Iceland, Ireland, Italy and Denmark where the peak was in 2007:Q3 or Q4. As regards the overall change since 2007:Q3, Australia, Belgium and Finland show a rise in investment up to the last observation. The opposite extreme is shown in Iceland, where investment in 2009:Q1 was over 60% lower than at the outset, and Ireland, where it is nearly 30% lower, suggesting these were hardest hit by the crisis – as indeed proved to be the case. Investment is down more than 10% in Canada, Germany, Italy, Japan, New Zealand and the United States, while elsewhere the falls are less than 10% in the year to 2007:Q3 (albeit the fall is often greater from the peak in early 2008).

In Table 9, changes in some of the key determinants of investment, namely real GDP, real interest rates, share prices and the variances of asset prices, are shown. What factors

Table 8. **Business fixed investment in the financial crisis**

	AUS	AUT	BEL	CAN	DNK	FIN	FRA	DEU	GRC	ISL	IRL	ITA
2007:Q3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2007:Q4	101.7	99.9	103.5	100.4	104.4	107.4	101.8	103.5	98.6	79.4	111.6	100.7
2008:Q1	105.7	101.4	105.1	100.6	101.5	106.7	104.1	104.1	99.4	78.0	113.2	98.6
2008:Q2	108.9	102.6	106.3	99.9	104.6	102.8	102.9	102.9	103.2	65.2	88.7	98.6
2008:Q3	111.9	100.9	105.2	100.4	105.3	109.8	102.3	104.5	101.5	65.6	100.6	95.4
2008:Q4	112.6	97.4	103.0	96.1	97.6	105.1	99.4	100.8	105.9	64.2	75.1	87.7
2009:Q1	106.5		99.8	87.4	99.7	98.5	96.2	87.9		35.6		
	JPN	KOR	MEX	NLD	NZL	NOR	ESP	SWE	CHE	GBR	US	
2007:Q3	100.0	100.0		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
2007:Q4	100.9	104.2		99.1	101.6	100.4	101.6	102.1	102.0	102.8	101.6	
2008:Q1	106.0	102.9		104.9	102.8	100.0	100.9	106.9		100.1	102.1	
2008:Q2	104.4	103.6		107.2	108.8	101.5	100.3	104.8		103.2	102.5	
2008:Q3	99.8	103.7		106.3	97.4	99.7	96.9	103.8		100.8	100.9	
2008:Q4	93.2	97.0		99.2	94.8	100.9	91.9	99.3		99.2	95.5	
2009:Q1	85.3			91.6	87.1	96.8		90.9		90.5	84.4	

Source: OECD.

Table 9. **Key determinants of investment in 2006-08**

	AUS	AUT	BEL	CAN	DNK	FIN	FRA	DEU	GRC	ISL	IRL	ITA
DI												
2006	7.72	2.32	5.59	10.01	14.33	6.96	5.58	10.06	–2.37	23.06	4.75	3.41
2007	11.65	4.29	8.51	3.68	4.21	13.57	7.50	6.54	14.51	–24.54	19.01	2.14
2008	11.14	1.47	7.12	0.23	–3.96	4.84	2.62	5.25	Na	–27.18	–31.27	–5.02
DY												
2006	2.63	3.29	3.02	2.85	3.34	4.86	2.42	3.17	4.50	4.46	5.72	2.10
2007	4.19	3.04	2.60	2.53	1.65	4.09	2.26	2.59	4.04	5.51	6.00	1.46
2008	2.31	1.72	0.97	0.41	–1.20	0.83	0.33	0.95	2.93	0.34	–2.27	–1.04
IRLAR												
2006	0.90	1.85	1.54	1.64	1.82	2.16	1.40	3.24	0.84	0.38	0.34	2.21
2007	2.08	2.10	1.94	1.11	2.33	1.19	1.80	2.30	1.63	4.28	2.93	2.08
2008	–0.63	1.90	2.68	–0.35	0.32	2.27	1.75	2.47	1.36	–1.14	4.85	1.83
DSP												
2006	19.22	30.76	22.28	18.88	19.17	24.90	20.33	25.42	26.44	39.72	23.95	15.72
2007	20.67	16.37	13.04	13.40	23.96	24.39	11.70	24.23	22.31	28.35	6.60	9.77
2008	–20.95	–18.04	–29.12	–8.55	–22.67	–23.99	–25.24	–22.17	–32.77	–50.84	–44.71	–30.64
SPVAR												
2006	0.1485	0.2889	0.1252	0.1757	0.1317	0.1675	0.2228	0.1864	0.3905	0.6341	0.2364	0.1661
2007	0.1071	0.2623	0.1523	0.1438	0.1408	0.1522	0.2105	0.1667	0.3539	0.7155	0.2670	0.1839
2008	0.4734	1.5672	0.4562	0.2720	0.3137	0.3505	0.4646	0.4065	0.9704	11.7950	0.6442	0.3195
LRVAR												
2006	0.0328	0.0202	0.0210	0.0221	0.0351	0.0249	0.0273	0.0218	0.0232	0.7814	0.0576	0.0237
2007	0.0363	0.0238	0.0220	0.0194	0.0334	0.0266	0.0278	0.0238	0.0233	0.7372	0.0561	0.0254
2008	0.0644	0.0393	0.0290	0.0288	0.0394	0.0371	0.0346	0.0348	0.0263	7.5117	0.0605	0.0324
ERVAR												
2006	0.0377	0.0022	0.0036	0.0236	0.0027	0.0074	0.0025	0.0052	0.0072	0.3873	0.0050	0.0032
2007	0.0795	0.0022	0.0037	0.0255	0.0025	0.0072	0.0022	0.0048	0.0065	0.1930	0.0046	0.0029
2008	0.2504	0.0023	0.0047	0.0447	0.0035	0.0082	0.0037	0.0058	0.0073	0.5918	0.0112	0.0058

Note: DI = difference of log of real business investment; DY = difference of log of real gross domestic product; IRLAR = long-term interest rate less GDP deflator; DSP = per cent change in share prices; ERVAR = annual average conditional volatility of nominal effective exchange rate [derived from GARCH (1,1) equations]; LRVAR = annual average conditional volatility of long-term interest rates [derived from GARCH (1,1) equations]; SPVAR = annual average conditional volatility of share prices [derived from GARCH (1,1) equations]. ERVAR and SPVAR are multiplied by 100 to allow for the log transform.

Table 9. **Key determinants of investment in 2006-8** *(cont.)*

	JPN	KOR	MEX	NLD	NZL	NOR	ESP	SWE	CHE	GBR	US
DI											
2006	2.32	7.63	n.a.	9.74	–0.31	14.46	7.80	9.10	7.45	–6.92	7.50
2007	5.68	6.98	n.a.	4.92	5.11	9.47	5.67	8.73	8.49	11.86	4.92
2008	–3.99	0.20	n.a.	7.05	3.54	7.42	–0.46	3.95	n.a.	1.68	1.63
DY											
2006	2.04	5.18	5.13	3.39	2.72	2.28	3.89	4.54	3.38	2.85	2.78
2007	2.34	5.11	3.32	3.61	2.97	3.13	3.66	2.70	3.33	2.56	2.03
2008	–0.72	2.22	1.38	2.00	–1.04	2.13	1.16	–0.39	1.63	0.74	1.11
IRLAR											
2006	2.64	5.30	0.80	2.01	–4.46	3.49	–0.26	2.25	0.80	1.72	1.57
2007	2.32	3.28	3.11	2.69	2.56	2.12	1.13	1.32	1.16	2.13	1.94
2008	2.36	2.81	1.45	1.48	–5.15	2.42	1.31	0.41	0.65	1.97	1.49
DSP											
2006	28.17	26.27	45.76	20.28	5.77	41.12	26.07	26.35	25.82	14.56	8.16
2007	2.25	26.71	40.99	12.91	10.69	24.54	21.80	18.79	12.99	8.79	15.44
2008	–28.63	–10.56	–9.60	–24.92	–26.07	–19.29	–22.84	–30.30	–23.32	–18.25	–14.56
SPVAR											
2006	0.1658	0.2483	0.4405	0.1344	0.1100	0.3628	0.1533	0.2057	0.1682	0.1770	0.0805
2007	0.1739	0.2659	0.3449	0.1662	0.1096	0.2762	0.1507	0.1790	0.1629	0.1377	0.0921
2008	0.5361	0.3786	0.4224	0.5571	0.1634	0.9151	0.3606	0.4687	0.2303	0.5771	0.1721
LRVAR											
2006	0.0200	0.0891	0.2800	0.0229	0.0248	0.0447	0.0240	0.0353	0.0240	0.0235	0.0260
2007	0.0175	0.0734	0.0699	0.0219	0.0447	0.0426	0.0248	0.0345	0.0237	0.0268	0.0308
2008	0.0376	0.1165	0.2790	0.0302	0.0537	0.0433	0.0297	0.0354	0.0259	0.0409	0.0606
ERVAR											
2006	0.0394	0.0730	0.1447	0.0044	0.0154	0.0355	0.0242	0.0158	0.0132	0.0185	0.0127
2007	0.0412	0.0621	0.1190	0.0041	0.0170	0.0415	0.0242	0.0183	0.0139	0.0151	0.0119
2008	0.0656	0.1015	0.2222	0.0053	0.0191	0.0465	0.0245	0.0176	0.0273	0.0292	0.0182

Note: DI = difference of log of real business investment; DY = difference of log of real gross domestic product; IRLAR = long-term interest rate less GDP deflator; DSP = per cent change in share prices; ERVAR = annual average conditional volatility of nominal effective exchange rate [derived from GARCH (1,1) equations]; LRVAR = annual average conditional volatility of long-term interest rates [derived from GARCH (1,1) equations]; SPVAR = annual average conditional volatility of share prices [derived from GARCH (1,1) equations]. ERVAR and SPVAR are multiplied by 100 to allow for the log transform.

distinguish countries such as Denmark, Iceland, Ireland, Italy, Japan and Spain where investment fell in 2008, as well as the United States and Canada which saw sharp subsequent falls? Of course, banking problems affected Iceland, Ireland and the United States severely, but the question remains whether these operated via normal cyclical variables or whether they were additional, owing for example to credit rationing which would not be captured by the conventional variables. For example, Denmark, Ireland, Italy and Japan saw a fall in GDP in 2008 which helps explain the fall in investment, given the estimated short-run elasticity with respect to output of over 2. New Zealand and Sweden on the other hand saw output fall but investment held up over the year as a whole, while in Spain investment fell despite a slight rise in GDP. It has to be borne in mind that the existing stock of capital and its utilisation rate is also a factor in investment decisions, and in Spain there is a major overhang of unsold residences.

As regards real long rates, these fell sharply in 2008 in most countries, albeit insufficiently to stem the decline in investment growth. In 2008, long real rates were negative in Australia, Canada, Iceland and New Zealand. The heaviest falls in long rates were in Iceland and Ireland, which experienced acute banking difficulties and (for Iceland) a currency crisis also.

Looking finally at the volatility of asset prices, the conditional variance of share prices rose in all countries, but especially where markets are relatively thin, for example in Greece, Austria and New Zealand, as well as in Ireland and Iceland which experienced acute banking crises. Long rate volatility rose markedly in Iceland, but also more than doubled compared with 2007 in Australia, Japan, Mexico and the United States. Elsewhere, for example in Norway, Sweden and Switzerland, it was little changed. As regards exchange rate volatility, again besides Iceland and Ireland it rose markedly in Mexico, the United Kingdom, Switzerland and Italy.

On balance, none of these measures correspond perfectly with the relative declines in investment, but it is notable that Iceland and Ireland are the hardest hit according to most of these indicators. The results are hence consistent with an additional effect of banking crises on uncertainty and credit rationing, over and above conventional determinants in investment functions, as suggested by Davis and Stone (2004).

In order to underpin these descriptive comments, a simple cross-sectional regression was estimated using the main variables of the panel work to decompose the factors underlying the falls in investment in 2008. This is tentative work, but potentially illuminating. We regressed the fall in investment in 2008, and also the sharper fall over 2009:Q1/2008:Q1 on annual changes in GDP, share prices, real interest rates, and share price, exchange rate and long rate volatility as well as the main lagged levels variables.

Using most levels terms in cross section requires demeaning (which in a panel is taken care of by the fixed effects). Intuitively, countries may have different mean levels of the debt/equity ratio, share of bank lending and the investment/GDP ratio, relating to the economic and financial structure so that simply inserting levels is unlikely to be meaningful. Instead, what could be relevant is to see whether the 2007 (*i.e.* lagged) level of these variables is higher or lower than it's country-mean, and whether that cross-country difference helps to explain the fall in investment. We exclude the long-term real rate as its effect should be broadly homogeneous across countries. Note that Q cannot be used as there are very few observations for 2007. Tentative results are shown in Table 10. We have cross-section data for 20 countries for the year of 2008 over the year of 2007.[18]

Table 10. **Cross section regression for the fall in investment**

	2008 over 2007	
Variable	Coefficient	t-statistic
C	8.079910	1.7
DY	4.902112	4.8
DSPVAR	–1.599140	–2.2
IRLAR07	–4.571209	–2.0
Adjusted R-squared	0.704655	
S.E. of regression	5.764113	
Sum squared residual	531.6000	
Log likelihood	–61.18036	
Observations	20	

Note: DY = difference of log of real gross domestic product; IRLAR07 = long-term interest rate less GDP deflator in 2007; DSPVAR = change in annual average conditional volatility of share prices [derived from GARCH (1,1) equations].

The result for 2008 on 2007, in line with the investment functions over time, features a strong positive income effect (with a coefficient of 4.9). Also negative effects of uncertainty as proxied by the rise in share price volatility in 2008 can be detected. There is a negative sign on the lagged long-term interest rate, but no significant balance-sheet variable effects were found. Accordingly, the fall in investment was partly a cyclical phenomenon, with falls in GDP leading to lower expected profitability. It also links to the relative cost of capital in the previous year and the level of uncertainty as proxied by share price volatility.

These cross-section results are tentative and more research is needed. Nevertheless, they are of interest as they show that it is indeed the conventional variables (output and cost of capital) as well as uncertainty proxies (based on conditional volatility) which can discriminate between countries on a cross-sectional basis, so as to explain in each case many of the differences in the fall in investment to the global shock of the 2008 financial crisis. Table 11 shows the allocation of effects as calculated by the equation. The errors are quite small in most cases, although one needs to be cautious in attributing economic as opposed to statistical importance to these calculations. The volatility measure, as well as the output variable, seems to be doing much of the "work" in discriminating between countries between 2007 and 2008. The change in investment is over-predicted most greatly in Ireland, Spain and the United States which were among those most affected by banking difficulties. This implies a credit rationing and uncertainty effect beyond that captured by the equation.

Table 11. **Decomposition of annual percentage change in investment using cross-section regression for 2008 over 2007**

	Actual	Fitted	Constant	DY	DSPVAR	IRLAR07
AUS	11.14	9.31	8.08	11.32	–0.59	–9.51
AUT	1.47	4.81	8.08	8.43	–2.09	–9.61
BEL	7.12	3.47	8.08	4.75	–0.49	–8.88
CAN	0.23	4.82	8.08	2.01	–0.20	–5.06
DNK	–3.96	–8.71	8.08	–5.88	–0.28	–10.63
FIN	4.84	6.39	8.08	4.07	–0.32	–5.44
FRA	2.62	1.07	8.08	1.62	–0.41	–8.22
DEU	5.25	1.59	8.08	4.66	–0.38	–10.76
ISL	–27.18	–27.56	8.08	1.67	–17.72	–19.59
IRL	–31.27	–17.06	8.08	–11.12	–0.60	–13.41
ITA	–5.02	–6.73	8.08	–5.10	–0.22	–9.50
JPN	–3.99	–6.66	8.08	–3.53	–0.58	–10.63
KOR	0.20	3.80	8.08	10.88	–0.18	–14.98
NLD	7.05	4.96	8.08	9.80	–0.63	–12.30
NZL	3.54	–6.79	8.08	–5.10	–0.09	–9.69
NOR	7.42	5.80	8.08	10.44	–0.09	–11.70
ESP	–0.46	8.27	8.08	5.68	–0.34	–5.16
SWE	3.95	–0.33	8.08	–1.91	–0.46	–6.03
GBR	1.68	1.27	8.08	3.63	–0.70	–9.74
US	1.63	4.53	8.08	5.44	–0.13	–8.86

Note: DY = difference of log of real gross domestic product; IRLAR07 = long-term interest rate less GDP deflator in 2007; DSPVAR = change in annual average conditional volatility of share prices [derived from GARCH (1,1) equations].

3. Conclusions

A survey of the literature on asset-price impacts on the real economy has shown a much wider range of work on consumption and related wealth effects than on investment. The existence of wealth effects on consumption *per se* is little contested, but there remains an issue of whether different effects should hold between countries and across assets. In terms of investment there is less work overall, partly reflecting poor results historically for

Tobin's Q, user cost and the financial accelerator. Nevertheless there are numerous studies implying that uncertainty and balance-sheet effects on investment can both be detected, albeit the latter more in micro than macro studies.

Overall, these results are crucial background to monetary policy setting, in particular during periods of rising asset prices. The widespread impact of such asset prices on real economic activity, and the succeeding banking crisis, may suggest a need for "leaning into the wind" during periods of boom, as suggested for example by Wadhwani (2008). This would have been a contrast with the "benign neglect" of rising asset prices by monetary policymakers during much of the decade, while interest rates remained low due to low CPI inflation. But equally it can be argued that fiscal policy should have been tighter in the boom, both to reduce the amplitude of deficits in the downturn but also because the structural deficits of expansionary fiscal policy may have boosted the upturn, leading consumers and firms to expect growth in excess of what was feasible.

In the light of the investment literature, panel-investment functions on a macro basis were estimated for up to 23 OECD countries. Developing earlier work, it was found that the main significant effects arising from asset prices come from the financial accelerator, credit channel and Tobin's Q (especially in the G7) and uncertainty as proxied by asset price volatility (especially in smaller OECD countries). There is also evidence for non-linearities in volatility.

The absence of balance-sheet effects in the small countries besides data quality and short data periods could be due to close banking relationships that overcome credit constraints, or heterogeneous corporate sectors where equity markets and hence related macro indicators are dominated by globally active firms such as Nokia, as well as foreign multinationals. If there is little or no corporate bond market activity, as is often the case in small countries, the credit channel effect will be hard to identify at a macro level. Meanwhile, the absence of uncertainty effects for the large countries may be due to markets in these countries being less volatile owing to a wider range of participants and hence liquidity, large countries being less vulnerable to currency crises and tensions than smaller countries, and derivatives markets being better developed, enabling firms to better protect their cash flows against asset price volatility.

Given the importance of investment not only to short-term demand but also to the long-term supply potential of the economy, the possible links from policy to these investment determinants warrant close study by policymakers. For example uncertainty in smaller economies may be mitigated by fixing exchange rates and ultimately joining currency unions, while in respect of the other channels the points noted above regarding monetary and fiscal policies apply strongly.

Descriptive analysis as well as tentative cross-sectional regression showed that both balance sheet and uncertainty channels played a role in the recent financial crisis, when investment fell sharply, although the simple accelerator was also important. Unexplained falls in investment were often greater in countries most affected by banking problems. The collapse in investment during the crisis and its impact on future supply potential of the OECD economies underlines the importance of appropriate banking regulation to seek to prevent future crises. There is a need both for more bank capital and cyclically-varying capital buffers to offset pro-cyclicality (Barrell *et al.*, 2010b).

Notes

1. The NiGEM model (*National Institute Global Econometric Model*) is a global econometric model developed by the UK National Institute of Economic and Social Research. NiGEM is based on estimation, and is used for policy analysis and forecasting. It is structured around the national income identity, can accommodate forward-looking consumer behaviour and has many of the characteristics of a Dynamic Stochastic General Equilibrium (DSGE) model, except that unlike a pure DSGE model, NiGEM is based on estimation using historical data.
2. Based on a Hodrick-Prescott filter.
3. Al-Eyd and Barrell (2005) explore the impact of liquidity-constrained behaviour on income and wealth channels operating in aggregate consumption and investigate the dynamic implications this has for fiscal policies in Europe.
4. Some studies used other definitions of financial wealth such as gross financial wealth (Bertaut, 2002) and stock-market capitalisation (Ludwig and Slok, 2004), but the bulk of the literature considers that these are theoretically and practically inferior to either net financial wealth or net total wealth. This is because net wealth is the most accurate indicator of households' balance-sheet position which they will use in making their decisions to consume. Against this, one could potentially argue that one of the key aspects of rising asset prices is the ability of households to take on more debt for consumption. Depending on the strength of this relationship, increasing real-asset prices could potentially result in a substantially lower impact on the net financial position if more debt is taken on for consumption. This would suggest including both real and net financial wealth, as in studies cited in Section 1.2.3.2.
5. The pooled mean group approach to panel estimation typically allows for differing short-run effects but tests for similar error-correction or long-run effects.
6. Note that elasticities from log equations need to be adjusted by the consumption-wealth ratio to obtain the mpcw. So unless the ratio is the same, equal elasticities do not imply equal mpcws.
7. This measure meets the difficulty that stocks in a national market may be owned by foreigners rather than residents, while domestic investors may hold foreign stocks. Only national balance-sheet data on wealth can overcome these difficulties.
8. Against the idea that income-expectations are the explanation for a link of consumption to housing, there is the observation that affordability indices for housing (*e.g.* house price/income ratios) have deteriorated in recent years.
9. Poterba and Samwick (1995) find a more important wealth effect for consumption of durable goods than for non-durable goods and services in the United States.
10. Indeed, Lettau and Ludvigson (2002) show that Q has a stronger relationship with other variables such as bond yields, the gearing ratio, the growth in debt and stock returns than with investment *per se*.
11. See Byrne and Davis (2003b).
12. Other studies, including Byrne and Davis (2004) looking at US inflation uncertainty, have found macro as well as financial effects, however.
13. For a study linking firm size to macroeconomic uncertainty, see Ghosal and Loungani (2000).
14. A set of results using CPI is available from the author on request. In practice, the results for CPI and PGDP are very similar for the various tests of asset price effects. It is in its ability to capture the cost of capital effect on investment that PGDP stands out.
15. The Im Pesaran Shin (2003) test for panel-unit roots is the average of Dickey Fuller tests for the individual country series allowing for heterogeneous deterministic intercept terms.
16. The results are consistent with Jones (1995) who reports evidence of increasing investment/output ratios for the industrialised countries in the post-war period and Davis and Madsen (2008) who note a sharp rise in the capital/output ratio in the major industrial countries. It may also be linked to an increase in the depreciation rate (where the basic model assumes a constant rate) and increased capital mobility as well as a decline in the relative price of capital goods.
17. Two further checks which were unsuccessful were: first using the shorter sample, and seeking to integrate both the level and variance terms in a general equation for investment, but the results did not add value and they are not reported. For the G7 significant wrong-signed volatility terms for long rates were found and a significant debt-equity. For all countries, there is only a significant lagged long-rate volatility effect, but again with the wrong sign due to the short sample. And for

smaller countries, there is only a significant lagged long-rate volatility effect with the correct sign. Second, using the intuition that credit constraints are more likely to bind in a recession, while credit is more freely available in an upturn, switching regressions between Q in a boom and the debt/equity ratio in a recession were estimated. But unfortunately the results were not favourable to the hypothesis – Q tended to be significant but not the financial accelerator or credit channel.

18. In Davis (2010) we also report results for 2009:Q1 on 2008:Q1, which are however less well determined, with GDP growth and exchange rate volatility being the significant variables.

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ANNEX

Data availability

	AUS	AUT	BEL	CAN	DNK	FIN	FRA	DEU	GRC	ISL	IRL	ITA
Quarterly data												
Real business investment	60:1-09:1	60:1-08:4	60:1-09:1	61:1-09:1	71:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-07:4	60:1-09:1	60:1-08:4	60:1-08:4
Nominal business investment	60:1-09:1	60:1-08:4	60:1-09:1	61:1-09:1	71:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-07:4	60:1-09:1	60:1-08:4	60:1-03:4
Deflator for business investment	60:1-09:1	60:1-08:4	60:1-09:1	61:1-09:1	71:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-07:4	60:1-09:1	60:1-08:4	60:1-03:4
Real GDP	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-08:4	60:1-09:1
Nominal GDP	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-08:4	60:1-09:1
Deflator for GDP	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-08:4	60:1-09:1
CPI	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-08:4	60:1-09:1
Monthly data												
Long-term interest rate	69:7-09:9	64:11-09:9	60:1-09:9	60:1-09:9	60:1-09:9	60:12-09:9	60:1-09:8	60:1-09:9	97:1-09:8	92:1-09:9	70:12-09:8	60:1-09:8
Effective exchange rate	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8
Share price index	60:1-09:8	60:1-09:8	60:1-09:8	60:1-09:8	60:1-09:8	60:1-09:8	60:1-09:8	60:1-09:8	65:1-09:8	88:10-09:8	93:1-09:8	60:1-09:8	60:1-09:8
Annual data												
Market value of firms	87-07	95-07	94-07	70-07	94-07	95-07	95-07	91-07	95-07		01-07	95-07
Stock of bank lending to firms	87-07	95-07	94-07	70-07	94-07	95-07	95-07	91-07	95-07		01-07	95-07
Stock of bond issues by firms	87-07	95-07	94-07	70-07	94-07	95-07	95-07	91-07	95-07		01-07	95-07
Nominal net capital stock	60-05	76-05	95-05			75-05	78-05	91-05				80-05
Real net productive capital stock	84-07	84-05	84-04	84-08	84-05	84-05	84-08	84-08			84-07	84-08
User cost of capital	84-07	84-05	84-04	84-08	84-05	84-05	84-08	84-08			84-07	84-08

	JPN	KOR	MEX	NLD	NZL	NOR	ESP	SWE	CHE	GBR	USA
Quarterly data											
Real business investment	60:1-09:1	75:1-08:4	80:1-96:4	60:1-08:4	61:3-08:4	62:1-09:1	64:1-08:4	63:1-09:1	90:1-07:4	66:1-09:1	60:1-09:1
Nominal business investment	60:1-09:1	75:1-08:4	80:1-96:4	60:1-08:4	61:3-08:4	62:1-09:1	64:1-08:4	63:1-09:1	90:1-07:4	66:1-09:1	60:1-09:1
Deflator for business investment	60:1-09:1	75:1-08:4	80:1-96:4	60:1-08:4	61:3-08:4	62:1-09:1	64:1-08:4	63:1-09:1	90:1-07:4	66:1-09:1	60:1-09:1
Real GDP	60:1-09:1	70:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	65:1-09:1	60:1-09:1	60:1-09:1
Nominal GDP	60:1-09:1	70:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	65:1-09:1	60:1-09:1	60:1-09:1
Deflator for GDP	60:1-09:1	70:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	65:1-09:1	60:1-09:1	60:1-09:1
CPI	60:1-09:1	60:1-09:1	69:1-09:1	60:2-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	91:1-09:1	60:1-09:1
Monthly data											
Long-term interest rate	66:6-09:8	82:5-09:8	78:1-09:9	60:1-09:9	70:1-09:9	61:9-09:9	66:1-09:9	60:1-09:9	60:1-09:9	60:1-09:9	60:1-09:9
Effective exchange rate	70:1-09:8	70:1-09:8	88:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8
Share price index	60:1-09:8	78:1-09:8	84:1-09:8	60:1-09:8	01:1-09:8	60:1-09:8	61:1-09:8	60:1-09:8	89:1-09:8	60:1-09:8	60:1-09:8
Annual data											
Market value of firms	80-07	02-07	97-07	90-07		89-07	89-07	95-07	99-07	87-07	60-07
Stock of bank lending to firms	80-07	02-07	97-07	90-07		89-07	89-07	95-07	99-07	87-07	60-07
Stock of bond issues by firms	80-07	02-07	97-07	90-07		89-07	89-07	95-07	99-07	87-07	60-07
Nominal net capital stock	96-05			87-05		70-05		00-05		60-08	70-05
Real net productive capital stock	84-07			84-05	84-06		84-06	84-06	84-06	84-05	84-08
User cost of capital	84-07			84-05	84-06		84-06	84-06	84-06	84-05	84-08

Source: OECD, IMF (share prices), United Kingdom (nominal net capital stock).

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